A CAHNERS PUBLICATION
INTERNATIONAL EDITION
APRIL 26, 1990

EDN®

The Electro/90 Show: Sessions and Products

Designer's guide to dc current sources

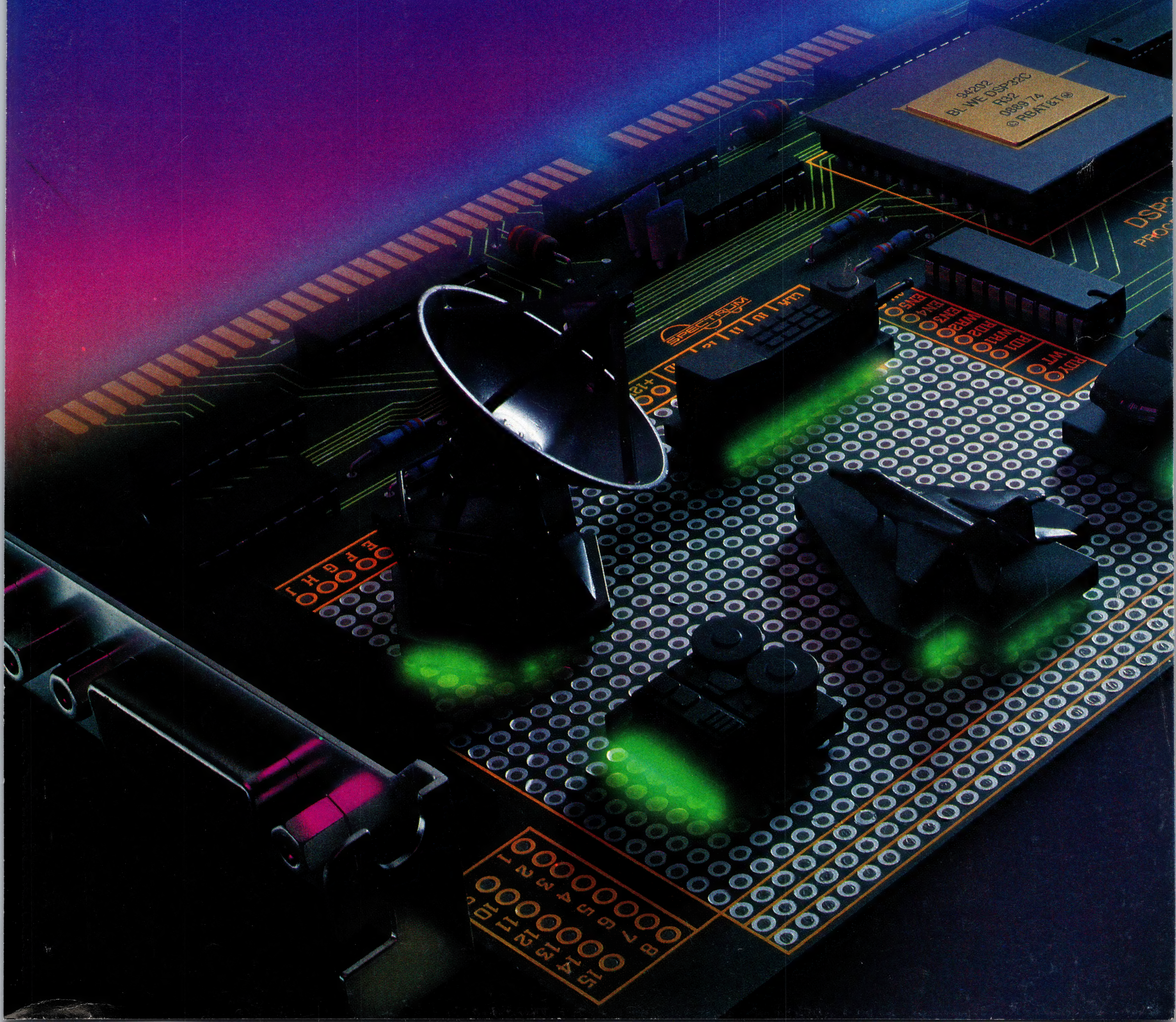
Use C function pointers to build control systems

EDN's All-Star PC—Pt 4

18 MAY 1990

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Plug-in DSP boards shine in specialized applications



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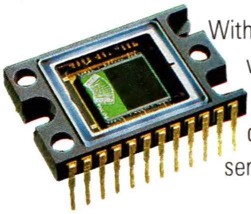

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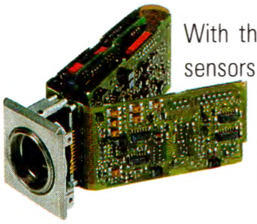

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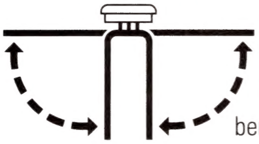

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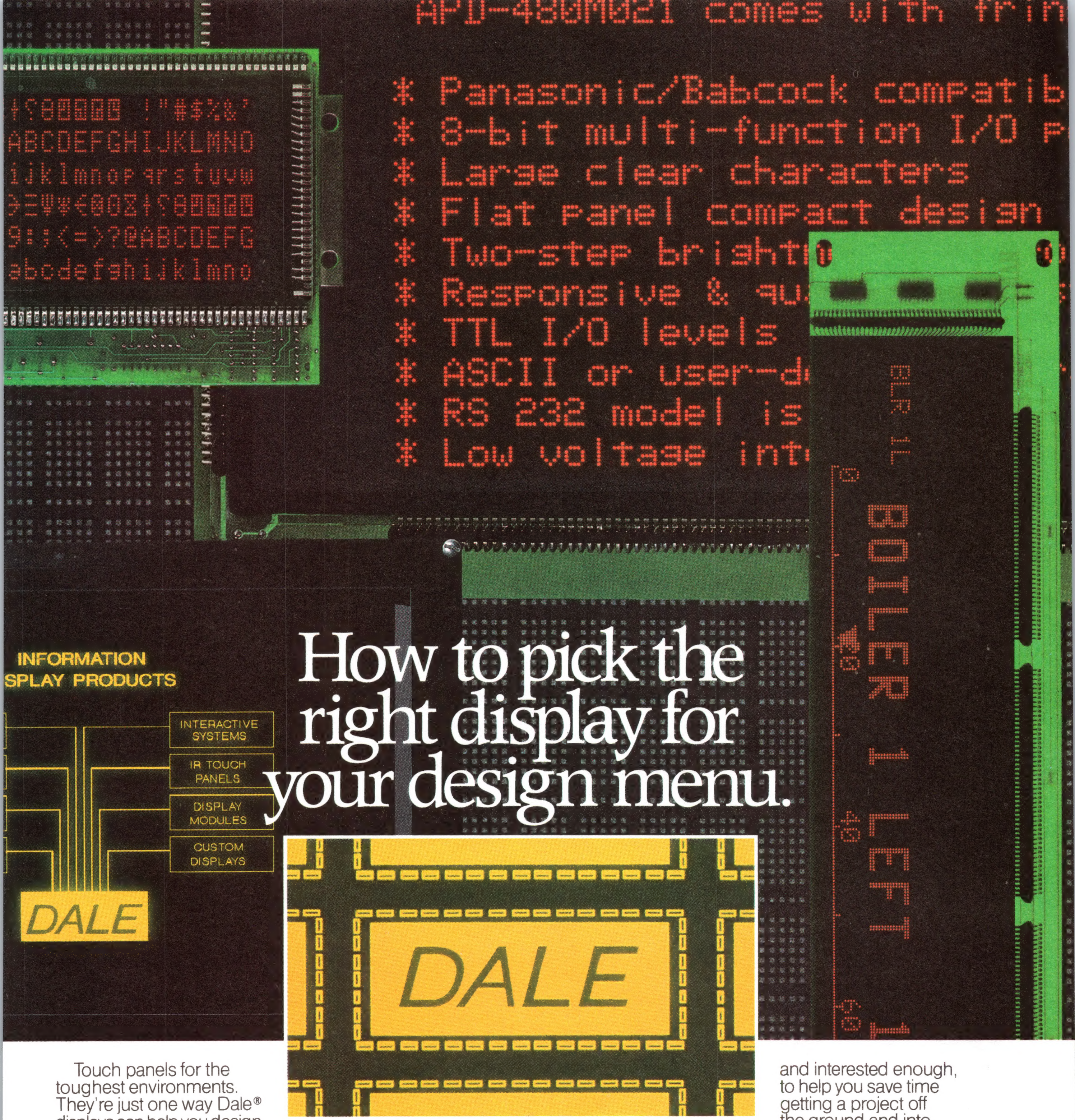

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F137 REV. ORIG.

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Insert. Loss (dB)	typ.	max.	typ.	max.
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100-1500MHz	1.1	**1.9**	1.1	1.7
1500-3000MHz	1.8	**2.7**	1.8	2.5
Isolation(dB)	typ.	min.	typ.	min.
10-100MHz	60	40	60	40
100-1500MHz	40	**28**	40	30
1500-3000MHz	35	22	35	22
1dB Compression(dBm)	typ.	min.	typ.	min.
10-100MHz	17	6	17	6
100-1500MHz	27	19	27	19
1500-3000MHz	30	28	30	28
VSWR(ON)	typ. 1.3	max. 1.6	typ. 1.3	max. 1.6
Switching Time (μsec) (from 50% TTL to 90% RF)	typ. 2.0	max. 4.0	typ. 2.0	max. 4.0
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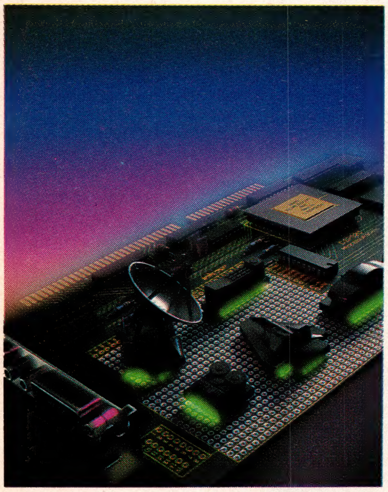
Volume 35, Number 9

April 26, 1990

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Plug-in DSP boards suit diverse, specialized applications and play an increasingly important role in sophisticated data analysis. See the Special Report on pg 142. (Photo courtesy Spectrum Signal Processing; concept by Uhlan Graham Eagle Advertising/Marketing, photography by Mel Lindstrom)*

SPECIAL REPORT

Plug-in DSP boards 142

With the aid of these lightning-fast DSP math crunchers, host computers can compute complex DSP algorithms that execute in faster than 30M flops.—*John Gallant, Associate Editor*

EDN's All-Star PC Project—Part 4 171

Just as a ballclub needs a pitcher and a catcher, EDN's All-Star PC needs software to be complete. The cardinal component of any software repertoire is the operating system. The All-Star PC uses several.—*Steven H Leibson, Senior Regional Editor*

INNOVATION™ *Driving Electronic Technology Into The Next Century*

DESIGN FEATURES

Designer's guide to precision dc current sources

—*Jerald Graeme, Burr-Brown Corp*

Part 1—Op amps turn voltage references into current sources 191

This 3-part series demonstrates the fine art of designing, analyzing, and trimming accurate, stable dc current sources. The first part begins with current-source basics and then analyzes several practical circuits, each of which requires only one op amp.

Part 2—In current sources, two amplifiers can be better than one 201

Part 2 discusses and analyzes circuits that use a pair of amplifiers. One of these circuits produces positive and negative current and lets you adjust the current through zero.

C function pointers let you build generic control systems 215

The C language has features that help you design a general-purpose program, which you can selectively compile for different applications.—*Rick Brown, Desert Research Institute, University of Nevada*

Continued on page 7

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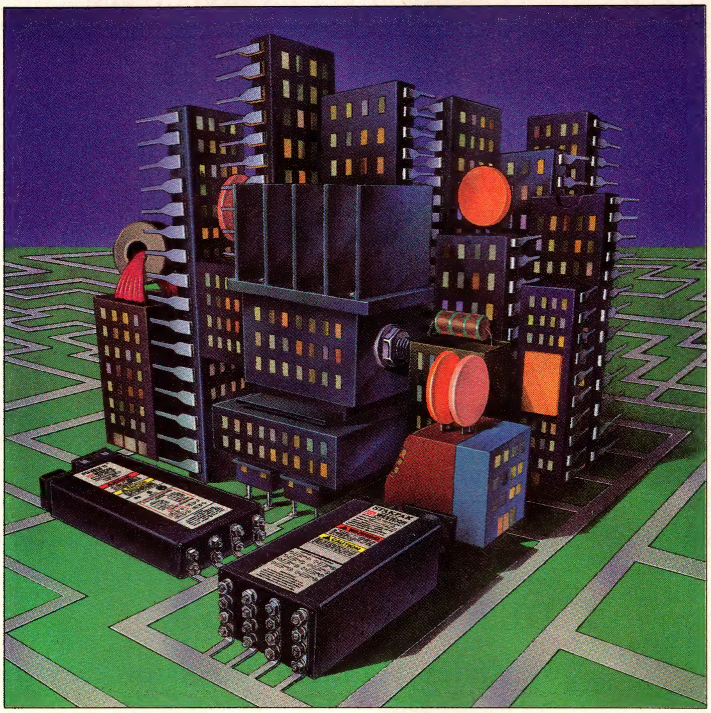

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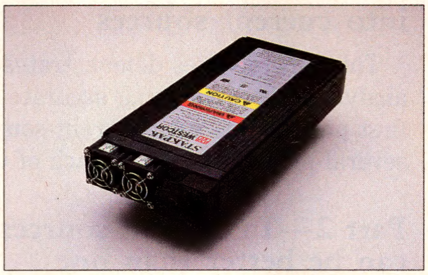
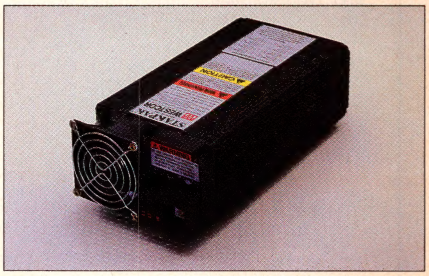
STAKPAK II STANDARD 600 WATT MODELS



Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel #1	#2	#3	#4	#5
Single Output					
ST1-1401	2 @ 120				
ST1-1402	5 @ 120				
ST1-1301	12 @ 50				
ST1-1302	15 @ 40				
ST1-1303	24 @ 25				
ST1-1304	28 @ 21				
ST1-1305	48 @ 13				
Dual Output					
ST2-1401	2 @ 60	5 @ 60			
ST2-1402	5 @ 60	5 @ 60			
ST2-1403	5 @ 60	12 @ 33			
ST2-1404	12 @ 33	12 @ 33			
ST2-1405	15 @ 26	15 @ 26			
Triple Output					
ST3-1401	5 @ 60	12 @ 16	12 @ 16		
ST3-1402	5 @ 60	15 @ 13	15 @ 13		
ST3-1501	5 @ 90	12 @ 8	12 @ 8		
Quad Output					
ST4-1401	5 @ 30	12 @ 16	12 @ 16	5 @ 30	
ST4-1402	5 @ 30	15 @ 13	15 @ 13	5 @ 30	
ST4-1403	5 @ 30	12 @ 16	12 @ 16	24 @ 8	
ST4-1501	5 @ 30	15 @ 13	15 @ 13	24 @ 8	
ST4-1502	5 @ 60	12 @ 16	12 @ 8	5 @ 15	
ST4-1503	5 @ 60	15 @ 13	15 @ 7	5 @ 15	
ST4-1504	5 @ 60	12 @ 16	12 @ 8	24 @ 4	
ST4-1505	5 @ 60	15 @ 13	15 @ 7	24 @ 4	
Five Output					
ST5-1501	5 @ 30	12 @ 16	12 @ 16	5 @ 15	24 @ 4
ST5-1502	5 @ 30	15 @ 13	15 @ 13	5 @ 15	24 @ 4

Total output power may not exceed 600 watts for any model, single or multiple output. Lower power StakPak II models and many other configurations are available. Please contact the factory.

STAKPAK STANDARD 1200 WATT MODELS



Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel #1	#2	#3	#4	#5
Single Output					
SP1-1801	2 @ 240				
SP1-1802	5 @ 240				
SP1-1803	12 @ 100				
SP1-1604	15 @ 80				
SP1-1605	24 @ 50				
SP1-1606	28 @ 42				
SP1-1607	48 @ 25				
Dual Output					
SP2-1801	2 @ 120	5 @ 120			
SP2-1802	5 @ 120	5 @ 120			
SP2-1803	5 @ 120	12 @ 66			
SP2-1804	12 @ 66	12 @ 66			
SP2-1805	15 @ 53	15 @ 53			
Triple Output					
SP3-1801	5 @ 180	12 @ 16	12 @ 16		
SP3-1802	5 @ 150	12 @ 33	12 @ 16		
SP3-1803	5 @ 180	15 @ 13	15 @ 13		
SP3-1804	5 @ 150	15 @ 26	15 @ 13		
Quad Output					
SP4-1801	5 @ 150	12 @ 16	12 @ 16	5 @ 30	
SP4-1802	5 @ 150	15 @ 13	15 @ 13	5 @ 30	
SP4-1803	5 @ 150	12 @ 16	12 @ 16	24 @ 8	
SP4-1804	5 @ 150	15 @ 13	15 @ 13	24 @ 8	
Five Output					
SP5-1801	5 @ 120	12 @ 16	12 @ 16	5 @ 30	24 @ 8
SP5-1802	5 @ 120	15 @ 13	15 @ 13	5 @ 30	24 @ 8
Seven Output					
SP7-1801	5 @ 60	12 @ 16	12 @ 16	24 @ 8	24 @ 8
	#6	#7			
	5.2 @ 28	2 @ 30			

Total output power may not exceed 1200 watts for any model, single or multiple output. Lower power StakPak models and many other configurations are available. Please contact the factory.

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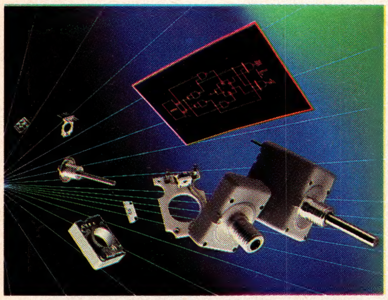
April 26, 1990



***Panel-mount optical encoders** provide a high-quality, long-life alternative to contact devices, although at greater cost (pg 57).*

TECHNOLOGY UPDATES

Panel-mount optical encoders: Long-lived devices offer high resolution 57

Panel-mount optical encoders are a reliable alternative to contact devices such as rotary switches and variable-resistance potentiometers. For these contact devices, a long lifetime is about 100,000 to 300,000 revolutions, whereas the shortest lifetime for an optical encoder is 1 million revolutions.—*Doug Conner, Regional Editor*

Electro/90 102

For three days in May, Boston will host the eastern United States' largest exposition for electronic design engineers. Electro/90 will offer nearly 50 technical sessions and 800 exhibits—all in a city that people love to visit.—*Dave Pryce, Associate Editor*

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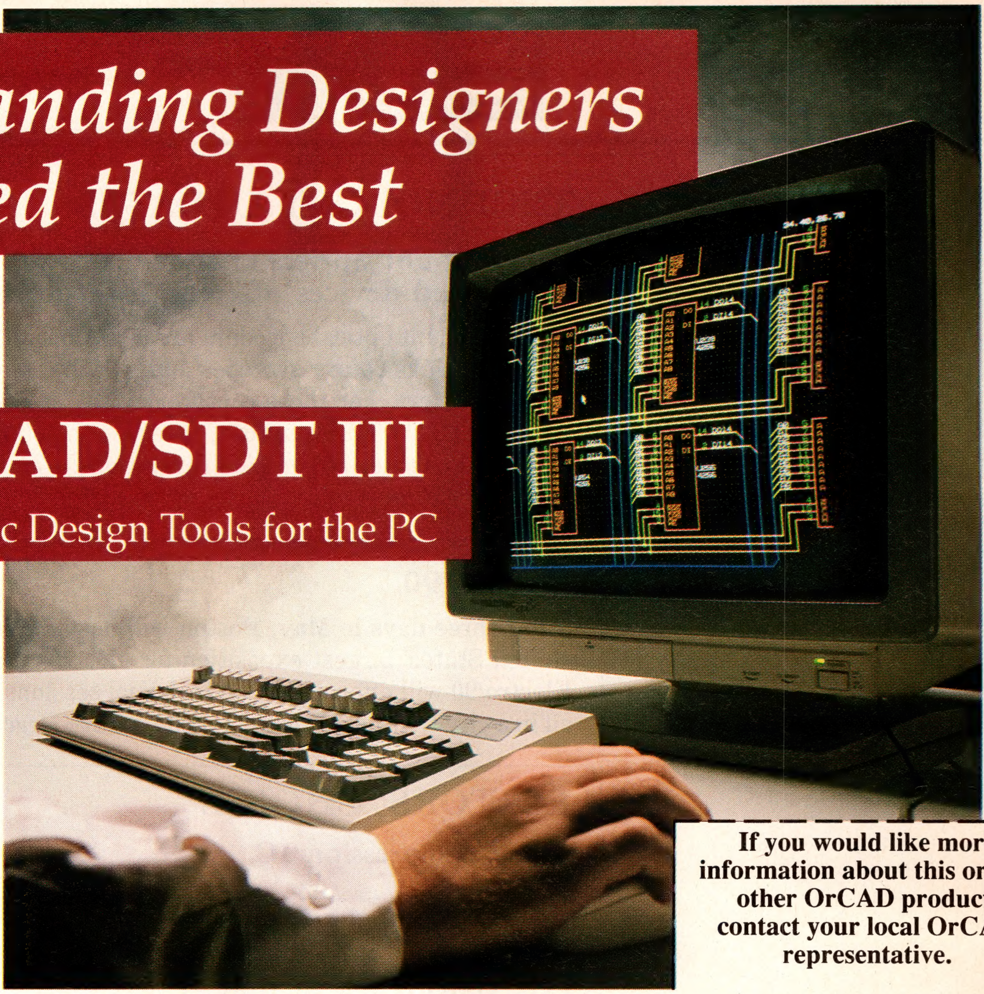
Demanding Designers Need the Best



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Look for communication technologies to pull the electronics industry out of its present slump.

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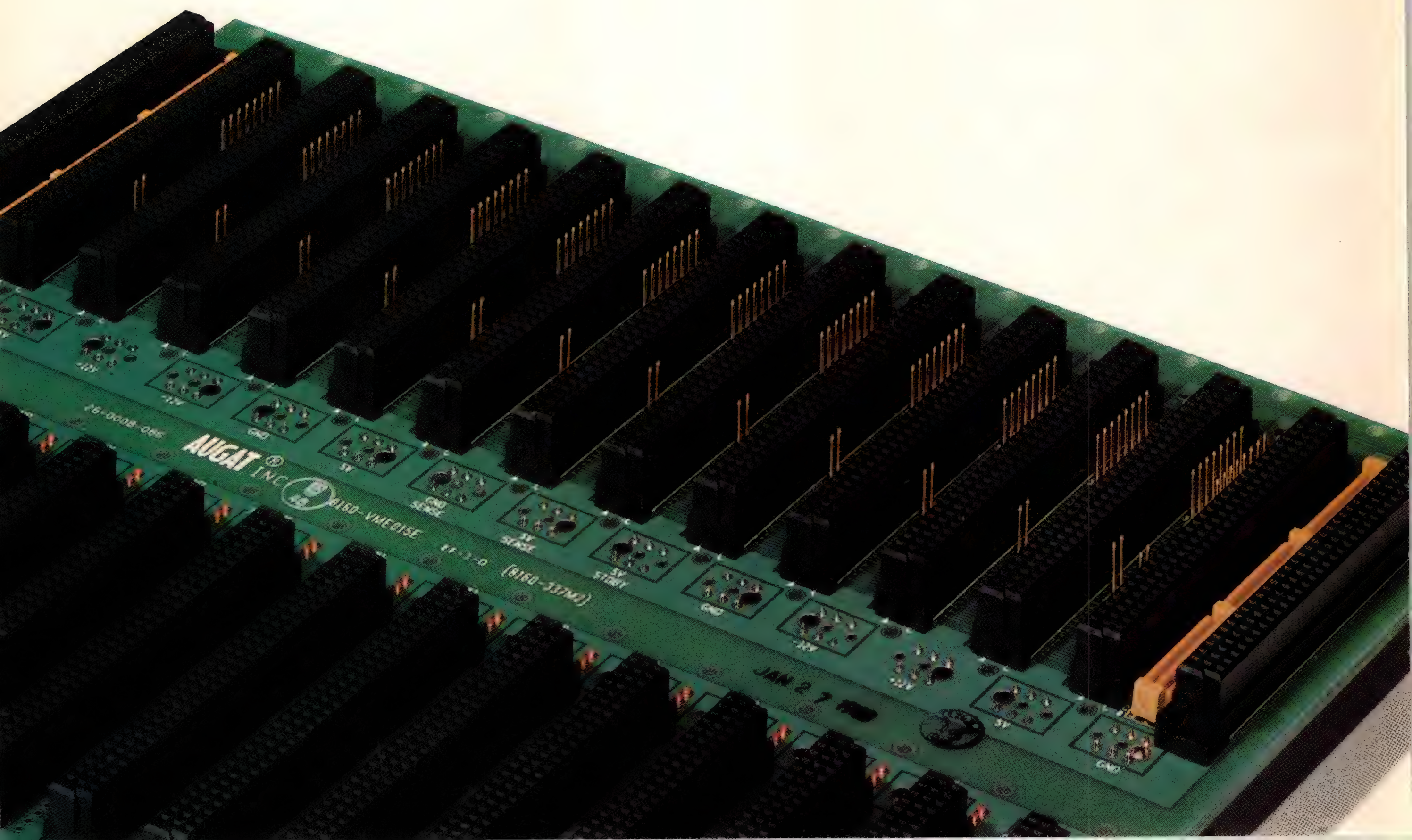

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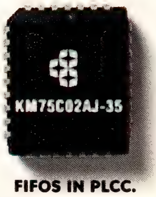

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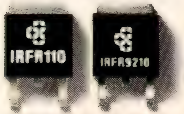
Samsung FIFOs include the fastest high-density parts made, and the industry's first programmable-flag FIFOs. Both are available in PLCC.



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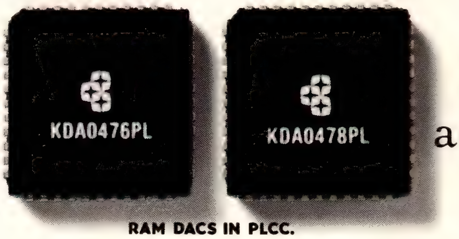
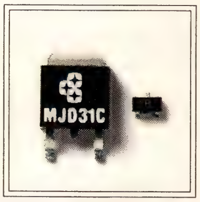
Unsurpassed in ruggedness, Samsung MOSFETs include 16 sought-after N-channel and P-channel parts in D-PACK.



RAM DACS IN PLCC.
The new Samsung high-speed 6-bit and 8-bit RAM DACs are now available, and both are offered in PLCC.



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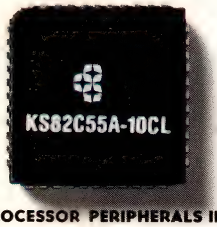

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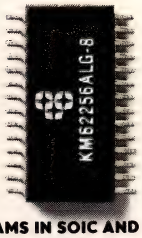

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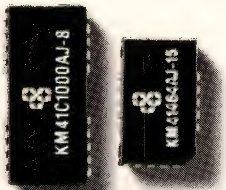
Our 8Kx8 and 32Kx8 slow SRAMs are both available in SOIC packaging.



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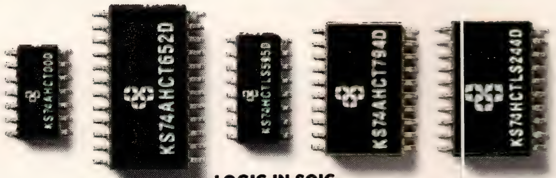

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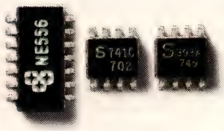
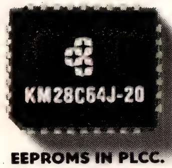
We offer every part in our advanced CMOS logic families, HCTLS and AHCT, in SOIC surface mount. 276 parts in all.



LINEAR IN SOIC.
Samsung makes one of the world's broadest families of linear devices, including many parts in SOIC.



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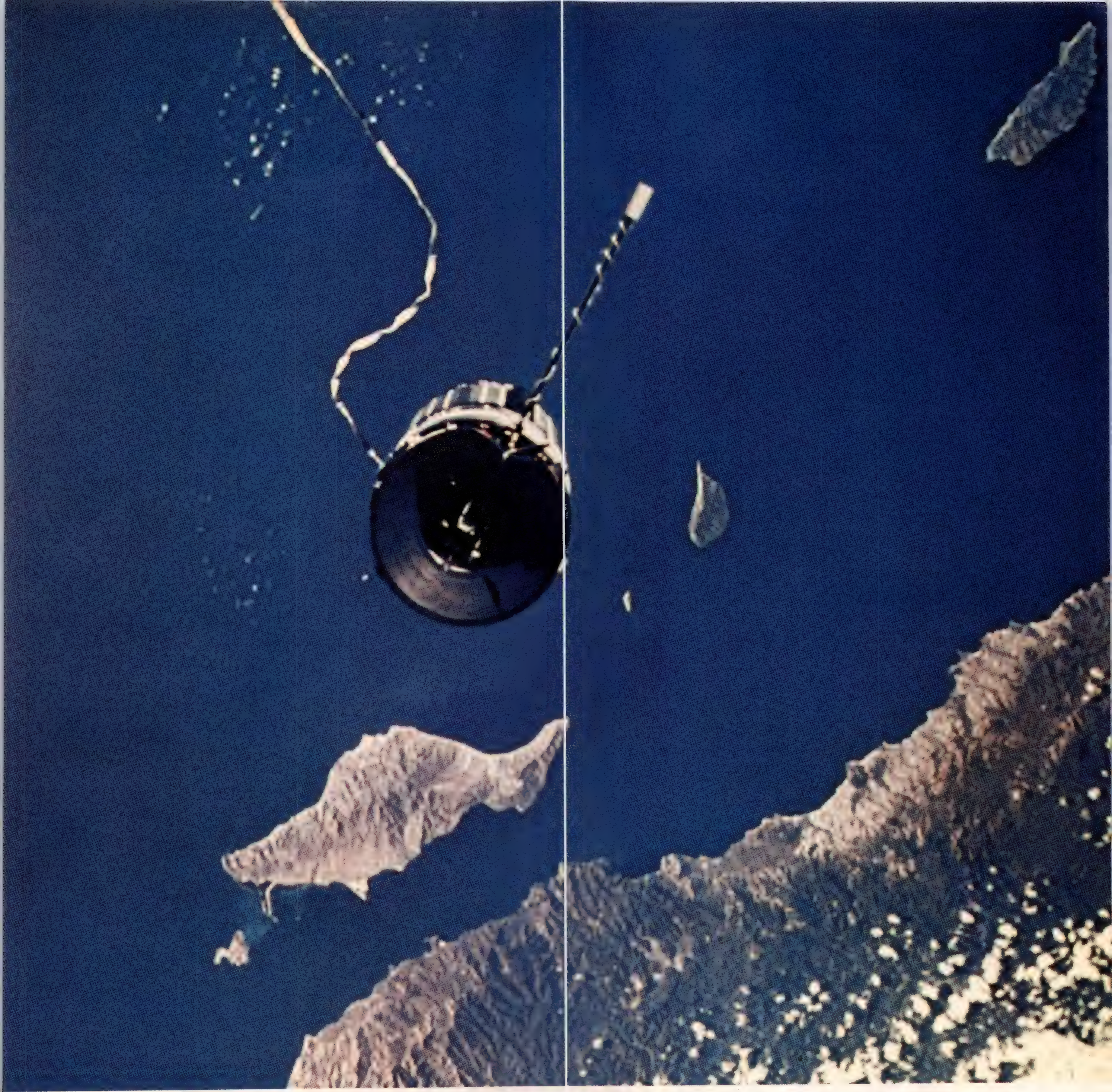

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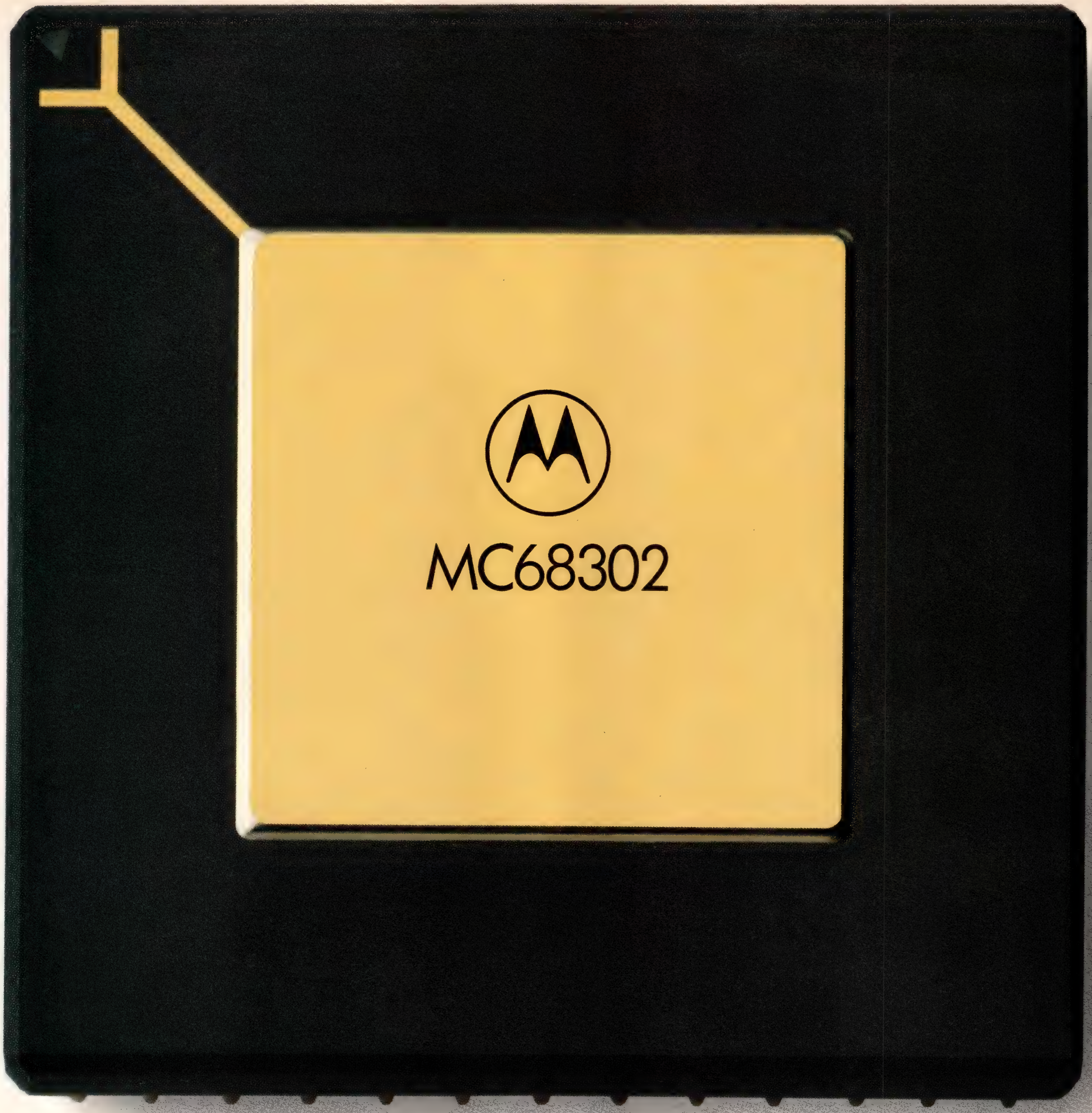

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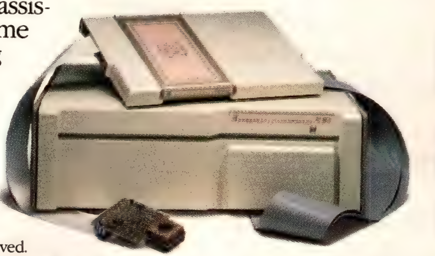

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CIRCLE NO. 21

NEWS BREAKS

EDITED BY JULIE ANNE SCHOFIELD

FLASH ADCs LOWER VIDEO DESIGNS' POWER REQUIREMENTS

Micro Power Systems' (Santa Clara, CA, (408) 727-5350) three new flash converters suit video and imaging applications. The 8-bit, 15-MHz MP8780 trades some speed—20 MHz is a more common encode rate for video converters—for low power, a small package, and low cost. The \$8.90 (100) device dissipates 300 mW max and comes in 24-pin DIPs and surface-mount packages. The converter features ±½-LSB dynamic differential linearity at 14.4 MHz. The two other flash converters are the 8-bit, 15-MHz MP7684A (\$13 (100)) and the 6-bit, 22-MHz MP7686 (\$6.61 (100)). The 8-bit converter dissipates 300 mW max and comes in 28-pin DIPs and surface-mount packages; the 6-bit converter dissipates 110 mW typ and comes in 18-pin packages.
—Anne Watson Swager

VHDL GIVEAWAY

Mentor Graphics (Beaverton, OR, (503) 626-7000) wants to speed the adaptation of VHSIC Hardware Description Language (VHDL) while stopping proprietary HDLs in their tracks. As a result, present and potential customers will save some money. Mentor is planning to include its VHDL product, System-1076, with the company's IdeaStation software update, Release 8.0 (see EDN, April 12, 1990). System-1076 combines a VHDL analyzer and an interactive, graphical source-code debugger with the vendor's other CAE tools. Additionally, you can mix and match models created using VHDL with those created using other modeling methodologies. Release 8.0's QuickSim logic simulator executes VHDL models directly. Mentor will provide the VHDL System-1076 software to all IdeaStation customers under maintenance as well as any customers who purchase IdeaStations this year. The software update is scheduled to be available in the third quarter of this year.—Michael C Markowitz

IEEE ADOPTS BOUNDARY-SCAN TEST STANDARD

The IEEE Standards Board adopted the boundary-scan test scheme originally developed by the Joint Test Action Group as IEEE Standard 1149.1 on February 15, 1990. The standard specifies a 4-pin test-access port. This port lets test equipment communicate with test circuitry incorporated into ICs on a pc board. The scheme employs synchronous, serial communications. IEEE plans to finish editing and to publish the standard within the next few months. Several semiconductor and test-equipment vendors are already developing products that exploit the standard.
—Steven H Leibson

DIGITAL ERROR CORRECTION MAINTAINS ADC's ACCURACY

The ML2261 8-bit A/D converter from Micro Linear (San Jose, CA, (408) 433-5200) uses internal error correction to provide a total unadjusted error—including nonlinearity, full-scale, and zero-scale errors—of ±½ LSB max. This spec applies across the full temperature range and a ±5% supply-voltage tolerance. The device converts a 0 to 5V signal at 250 kHz with a S/N ratio of 45 dB. The maximum conversion time is 660 nsec, or 755 nsec in the track-and-hold mode. The device is pin compatible with AC0820 and AD7820 converters and is available in a 20-pin DIP or surface-mount package. Prices start at \$8.95 (100).—Anne Watson Swager

NEWS BREAKS

PRODUCTS ENABLE SPARCSTATION CONTROL OF INSTRUMENTS

Products from IOtech (Cleveland, OH, (216) 439-4091) and National Instruments (Austin, TX, (800) 433-3488) will let users of Sun Microsystems' SPARCstation line of workstations control IEEE-488 instruments. The hardware portion of IOtech's $995 SB488 is a small board that plugs into Sun's proprietary S bus and allows data transfers as fast as 1M byte/sec. A software driver, compatible with SunOS 4.0.3c, supports a command set patterned after the one used by many Hewlett-Packard instruments. The heart of National Instrument's $1395 GPIB-SPARC1-S kit is a small, free-standing µP-based SCSI-to-IEEE-488 converter. The converter operates as fast as 900k bytes/sec and internally converts SCSI protocol to IEEE-488 protocol. The kit also includes multitasking software. RAM buffers that store 64k and 256k bytes increase the kit's price by $100 and $300, respectively.—Dan Strassberg

COPROCESSOR FOR 80386SX REDUCES POWER DISSIPATION

The FasMath 83S87 math coprocessor from Cyrix Corp (Richardson, TX, (214) 234-8388) suits laptop computers and embedded controllers. The chip is pin compatible with Intel's 80386SX µP. Its current consumption is less than 5 mA when idling and less than 40 mA when operating in a 16-MHz system. These specs result in one-fortieth the idle-mode power dissipation and one-fifth the active power dissipation of the 80387SX. The chip exceeds the floating-point performance of Intel's 80387SX coprocessor by as much as five times because the 83S87 implements its floating-point primitive operations in hardware rather than in a microprogrammed sequencer. For example, the 83S87 handles floating-point multiplication operations in 10 to 22 clock cycles; the 80387SX coprocessor takes as many as 87 clock cycles. Eight 80-bit internal stack registers store data and handle computations. The chip implements transcendental functions and is 100% compatible with software written for the 80386SX µP. The 16- and 20-MHz versions cost $506 and $556, respectively.
—John Gallant

DSP FAMILY ADDING LOWER-COST FLOATING-POINT MEMBERS

The TMS320 family of DSP µPs from Texas Instruments (Houston, TX, (800) 232-3200, ext 700) is gaining two more floating-point members. The TMS320C30-26 is object-code- and pin-compatible with the vendor's TMS320C30 but runs slower and costs less than its predecessor. In contrast to the TMSC320's 60-nsec cycle time and 33-flops and 17-MIPS performance figures, the TMSC320-26 has a 75-nsec cycle time and delivers 26 flops and 13 MIPS. The chip is available now for $100 (10,000). The TMS320C31 adds the following features to the TMS320C30: a 32-bit CPU, a hardware multiplier, a 2k-word dual-access RAM, a 64-word program cache, a DMA controller, a serial port and timer, an external 32-bit data bus, and a 24-bit address bus. It runs on a 26-MHz clock. Samples will be available in the fourth quarter of 1990; production volumes are expected in 1991 and will cost $25 to $35 (OEM qty).
—John Gallant and Richard A Quinnell

DESIGN KIT EASES CELLULAR-RADIO PRODUCT DESIGN

A $3000 cellular chip-set design kit from Philips Components-Signetics (Sunnyvale, CA, (408) 991-2000) can give you a head start designing products for cellular radios. The kit includes cellular-radio hardware and support software to help you design products using the company's 6-chip set.—Steven H Leibson

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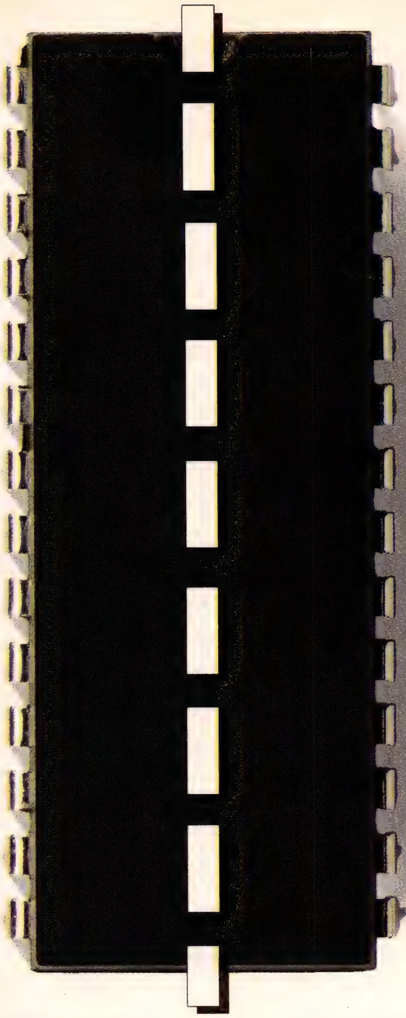

CY7C433. 4K x 9 FIFO, 25 ns/28.5 MHz, now available in ***half-width,*** *300-mil DIP.*

Now the fastest cost you less space.

FIFO memories have caught on in a big way as a tool to simplify the connection of asynchronous system elements.

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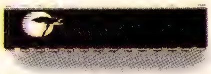
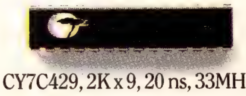
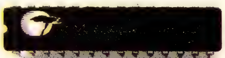


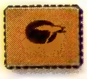
CY7C433, 4K x 9, 25 ns, 28.5 MHz.



CY7C429, 2K x 9, 20 ns, 33MHz.



CY7C425, 1K x 9, 20 ns, 33 MHz



CY7C421, 512 x 9, 20 ns, 33 MHz.

Data Book Hotline: 1-800-952-6300,* *Dept.C44*

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NEWS BREAKS

DELAY LINES FEATURE INDEPENDENT EDGE ADJUSTMENTS

The Bt622/624 dual and quad delay lines from Brooktree Corp (San Diego, CA, (619) 452-7580) let you independently control the widths and trailing edges of ECL 10KH-compatible signals. Two external adjustments, V_{DELAY} and V_{WIDTH}, adjust the delays of the leading and trailing edges, respectively. If no trailing edge adjustment is necessary, you can disable V_{WIDTH}'s control. The devices feature a 200-MHz bandwidth and 10-, 20-, or 30-nsec delay ranges. The chips also feature a fan-out mode, in which the device connects one input directly to the inputs of the other channels. The dual version costs $24; the quad version costs $32 (1000).—Anne Watson Swager

CONVERSION SERVICE EASES TRANSITION FROM FPGA TO ASIC

A software interface developed by Harris Semiconductor (Melbourne, FL, (407) 724-7000) lets you convert Xilinx field-programmable-gate-array (FPGA) designs into CMOS ASICs. Harris's software translates the FPGA-design net list into the company's HSC4000 standard cell and CGA200 gate-array products. The company claims that you can save money on the cost of devices by converting from the FPGA to an ASIC, although the savings will depend on the size of the ASIC and the production volumes. The conversion software not only transforms a design from the FPGA definitions to cells in the appropriate ASIC library, but also checks for design violations that the conversion might produce. The company includes the cost of conversion with its ASIC nonrecurring engineering charges, which start at $10,000.
—Steven H Leibson

COLOR MONITOR HAS 2048×2048-PIXEL RESOLUTION

Sony Corp's Precision Graphics Systems Div (San Diego, CA, (619) 673-2641) has announced the commercial availability of its Sony 20/20 color monitor. The monitor has a 20×20-in. screen and a 2048×2048-pixel resolution, thus it delivers three times the information 1280×1024-pixel color monitors deliver. The display is brighter than that of shadow-mask monitors, and the flat screen keeps distortion and light reflection to a minimum. You can align the monitor by computer via a digital interface and the company's software, or you can align it manually with the company's handheld alignment controller. Both the alignment software and the controller come with the monitor. The monitor suits high-performance imaging applications, such as air-traffic control, medical and scientific imaging, and CAD/CAE. The DDM-2801C model costs $40,000; the DDM-2802C model includes a cabinet and bezel and costs $47,300. The monitor is available in OEM quantities; delivery is five months ARO.—Julie Anne Schofield

CHIP SET SIMPLIFIES DESIGN OF SPARC-BASED WORKSTATION

Clone makers tired of copying the IBM PC can now set their sights on workstations. LSI Logic (Milpitas, CA, (408) 433-8000) has produced a 7-chip set that lets you build a workstation that's compatible with both the Unix and the SunOS operating systems. The set includes a SPARC-based 25-MHz integer processor, a floating-point unit, memory and cache controllers, an I/O controller, and a DMA controller. The set costs $1327 (1000); samples will be available in June.—Richard A Quinnell

RUGGED SOLUTIONS TO TOUGH DESIGN PROBLEMS.

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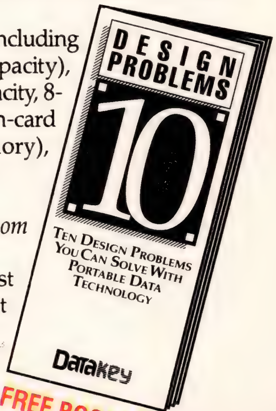
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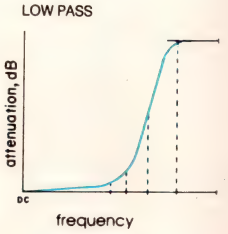
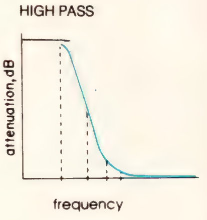


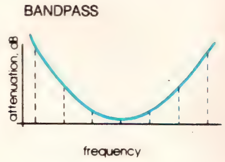
low pass dc to 1200MHz

MODEL NO.	PASSBAND, MHz (loss <1dB) Min.	fco, MHz (loss 3db) Nom.	STOP BAND, MHz (loss>20dB) Max.	(loss>40dB) Max.	Min.	VSWR pass-band typ.	stop-band typ.	PRICE $ Qty. (1-9)
PLP-10.7	DC-11	14	19	24	200	1.7	18	11.45
PLP-21.4	DC-22	24.5	32	41	200	1.7	18	11.45
PLP-30	DC-32	35	47	61	200	1.7	18	11.45
PLP-50	DC-48	55	70	90	200	1.7	18	11.45
PLP-70	DC-60	67	90	117	300	1.7	18	11.45
PLP-100	DC-98	108	146	189	400	1.7	18	11.45
PLP-150	DC-140	155	210	300	600	1.7	18	11.45
PLP-200	DC-190	210	290	390	800	1.7	18	11.45
PLP-250	DC-225	250	320	400	1200	1.7	18	11.45
PLP-300	DC-270	297	410	550	1200	1.7	18	11.45
PLP-450	DC-400	440	580	750	1800	1.7	18	11.45
PLP-550	DC-520	570	750	920	2000	1.7	18	11.45
PLP-600	DC-580	640	840	1120	2000	1.7	18	11.45
PLP-750	DC-700	770	1000	1300	2000	1.7	18	11.45
PLP-800	DC-720	800	1080	1400	2000	1.7	18	11.45
PLP-850	DC-780	850	1100	1400	2000	1.7	18	11.45
PLP-1000	DC-900	990	1340	1750	2000	1.7	18	11.45
PLP-1200	DC-1000	1200	1620	2100	2500	1.7	18	11.45



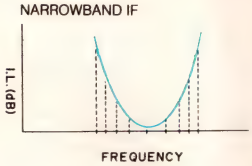
high pass dc to 2500MHz

MODEL NO.	PASSBAND, MHz (loss <1dB) Min.	Min.	fco, MHz (loss 3db) Nom.	STOP BAND, MHz (loss>20dB) Min.	(loss>40dB) Min.	VSWR pass-band typ.	stop-band typ.	PRICE $ Qty. (1-9)
PHP-50	41	200	37	26	20	1.5	17	14.95
PHP-100	90	400	82	55	40	1.5	17	14.95
PHP-150	133	600	120	95	70	1.8	17	14.95
PHP-175	160	800	140	105	70	1.5	17	14.95
PHP-200	185	800	164	116	90	1.6	17	14.95
PHP-250	225	1200	205	150	100	1.3	17	14.95
PHP-300	290	1200	245	190	145	1.7	17	14.95
PHP-400	395	1600	360	290	210	1.7	17	14.95
PHP-500	500	1600	454	365	280	1.9	17	14.95
PHP-600	600	1600	545	440	350	2.0	17	14.95
PHP-700	700	1800	640	520	400	1.6	17	14.95
PHP-800	780	2000	710	570	445	2.1	17	14.95
PHP-900	910	2100	820	660	520	1.8	17	14.95
PHP-1000	1000	2200	900	720	550	1.9	17	14.95



bandpass 20 to 70MHz

MODEL NO.	CENTER FREQ. MHz F0	PASS BAND, MHz (loss <1dB) Max. F1	Min. F2	STOP BAND, MHz (loss > 10 dB) Min. F3	Max. F4	(loss > 20 dB) Min. F5	Max. F6	VSWR 1.3:1 typ. total band MHz	PRICE $ Qty. (1-9)
PIF-21.4	21.4	18	25	4.9	85	1.3	150	DC-220	14.95
PIF-30	30	25	35	7	120	1.9	210	DC-330	14.95
PIF-40	42	35	49	10	168	2.6	300	DC-400	14.95
PIF-50	50	41	58	11.5	200	3.1	350	DC-440	14.95
PIF-60	60	50	70	14	240	3.8	400	DC-500	14.95
PIF-70	70	58	82	16	280	4.4	490	DC-550	14.95



narrowband IF

MODEL NO.	CENTER FREQ. MHz F0	PASS BAND, MHz I.L. 1.5dB max. F1-F2	STOP BAND, MHz I.L. > 20dB F5	F6	STOP BAND, MHz I.L. > 35dB F7	F8-F9	PASS-BAND VSWR Max.	PRICE $ Qty. (1-9)
PBP-10.7	10.7	9.5-11.5	7.5	15	0.6	50-1000	1.7	18.95
PBP-21.4	21.4	19.2-23.6	15.5	29	3.0	80-1000	1.7	18.95
PBP-30	30.0	27.0-33.0	22	40	3.2	99-1000	1.7	18.95
PBP-60	60.0	55.0-67.0	44	79	4.6	190-1000	1.7	18.95
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MSM514102-8XX MSM514102-10XX	4M x 1	Static Column	80 100
MSM514400-8XX MSM514400-10XX	1M x 4	Fast Page	80 100
MSM514402-8XX MSM514402-10XX	1M x 4	Static Column	80 100
Packaging Options Include: XX = 'JS'...350 mil SOJ 'RS'...400 mil DIP 'ZS'...400 mil ZIP			
MSC2340-XY59 Speed Options Include: X = '8'...80 ns. '10'...100 ns.	4M x 9	Fast Page	80, 100

Oki's advanced 4-Meg DRAM technology can ease the pressure. Our space-saving 4-Megx9 single inline memory module, 4-Megx1 and 1-Megx4 DRAMs offer the problem-solving advantages you need to simplify high-density design tasks. Like quadrupling memory with our 4-Megx9. Manufactured to JEDEC standard dimensions and pin-outs like our 1-Megx9, Oki's 4-Megx9 easily replaces the 1-Meg—saving valuable redesign time, increasing reliability, *and* cutting costs.

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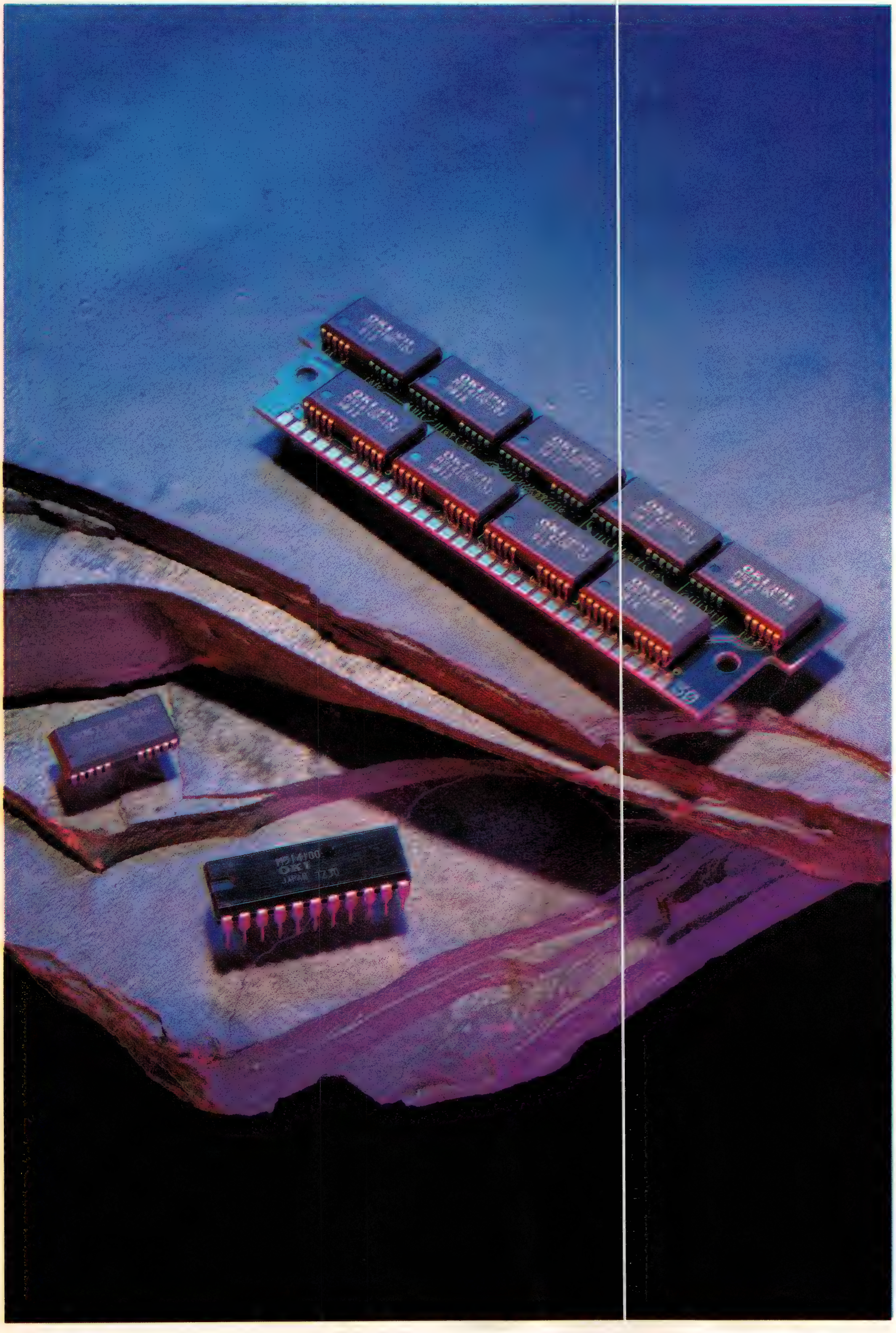

4 MeG
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CIRCLE NO. 24

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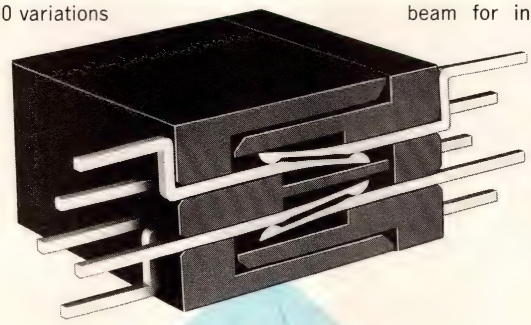
As presented at the IICIT Symposium in 1988 and 1989.

KEL Corporation has again responded to the industry's need for new connector solutions. Currently, we manufacture over 700 variations in the "Hi-PACKEL" system to satisfy a wide range of packaging requirements. The board mount, IDC, and I/O connectors all utilize the unique hermaphroditic contact design developed by KEL Corporation for 50 mil connectors.



The patented "Hi-PACKEL" contact design offers two independent mating points on a straight beam for increased reliability, performance, and connector life. The dynamic mating process is self-cleaning and provides lower insertion and withdrawal forces. The insulator prevents misinsertion and protects the contacts from damage. The end result is a reliable higher density connector.

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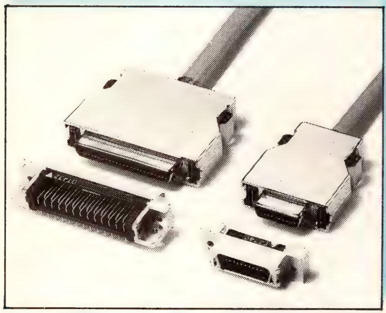

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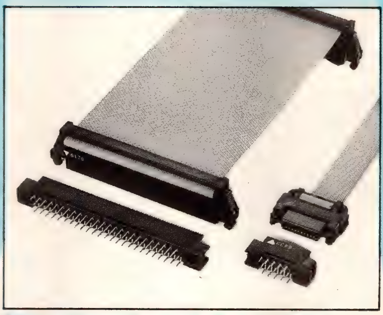

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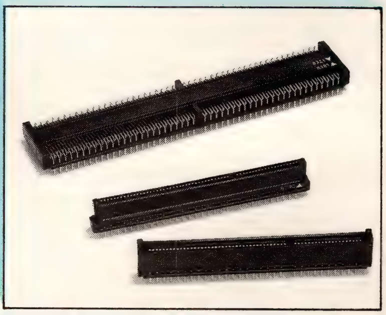

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CIRCLE NO. 25

SIGNALS & NOISE

Can America sleep well?

Three cheers for Max Schindler's letter (EDN, January 18, 1990, pg 32). Max correctly sees a major problem in America's being overly populated with lawyers. However, that's only the tip of the iceberg. An equally vexing problem is that the "People in Positions of Power" (3P) in our nation are more concerned with process than with product. From the prestige press to movie producers, from corporate boardrooms to the district attorney's office, everyone celebrates style over substance.

It's so bad in New York City that the district attorney's office impaneled a second grand jury to try to indict Bernhard Goetz for defending himself (after a first grand jury failed to indict him). One must surmise that the appearance of needing to defend oneself on New York City streets is such bad publicity that New York's 3P had to "get" this poor individual.

One fascinating aspect of this situation is how it relates to Jon Titus's editorial in the same issue (EDN, January 18, 1990, pg 47), where he calls for a decade of innovation to keep America competitive. This innovation, of course, falls on the shoulders of the engineering profession to invent, design, conceive, and otherwise midwife.

But engineers are on the lowest rung of the ladder of influence and reward for the fruits of their labors. A case in point: A fellow engineer's wife works as a recruiter for "executive positions." She told him a story of how a midsized corporation recently hired an individual as the "Director of Information Services" for an annual salary of $180,000. This individual's resume listed no training in technology of any sort. But he is now in a position to direct the work of engineers who graduated from a course curriculum that he himself probably couldn't pass.

With the downturn in the economy and cutbacks in defense, engineers are being laid off by people who either dropped out of engineering school and finished their degree in the school of management or who didn't cut the mustard to even make engineering school in the first place. With this foundation, you would call for a decade of innovation? I'm glad one of us is an optimist. Sleep well, America.

Bill Kamenel
Ocean, NJ

The bottom line boils down to supply and demand

I was completely shocked by Michael Markowitz's editorial, "Cut us in on profits, too" (EDN, November 23, 1989, pg 47). It's obvious to me that Michael has been an employee during the time of his professional career and does not see the business side of this story.

Has Michael heard of the words "partnership," "joint venture," and "corporation?" These words have to be implemented if engineers want to share part of the profits. How about a patent? Engineers design a product. They patent it. They share the profits.

On the other hand, engineers who are hired have an employee/employer relationship. The employer provides the environment and the weekly monetary incentives, and engineers produce intellectual work and at the same time gain professional satisfaction. If engineers are not happy with their compensation or the type of work they're doing, they can find another job.

To follow Michael's ideas, why don't all the people who build the products designed by engineers share in the profits? How about janitors who keep engineers' workplaces clean and allow engineers to concentrate on the work they are doing? Cut the janitors in for 10%—after all, they are making the working environment better.

Why do companies create all types of products? For the benefit of the world? If engineers say yes, they're dreaming. Money and profit are the driving forces in new developments and innovations (with some exceptions). Without these incentives, there would be no faxes, microwave ovens, or cars, for that matter. Ask Mr Ford (as in Ford cars). He will tell engineers. And if they need some proof, why don't they visit the USSR where there are no microwave ovens, no fancy calculators or digital watches, and no digitally controlled refrigerators? But there are famous entertainers like Magamaev and Slichenko.

There are enough engineers who are willing, eager, and ready to work and create for a fixed salary without royalties. But if some of them want to negotiate, they are out in the cold. On the other hand, there is only one Michael Jackson, one Steven Spielberg, and one Bill Cosby. Maybe engineers still remember from their school days the simple theory of supply and demand.

Who's paying all this money to Michael, Steven, and Bill? It's the people, including all the engineers, who enjoy that moment of satisfaction by watching a Jackson concert, "Back to the Future," or Bill Cosby's show. We pay and we love it. What would engineers do in their spare time if there were no Jackson, Spielberg, or Cosby? Enjoy their "HP" calculators? Let's ask all the engineers to boycott the entertainers. That will teach them a lesson, but it surely will not stop them from making a lot more money.

Jack Gershfeld
President
Inline Inc
La Habra, CA

(Ed Note: Contrary to Jack Gershfeld's assessment of engineers' backgrounds, most of them do un-

derstand the business implications of the EDN editorial suggestion. Although Jack suggests a patent as a way for design engineers to share in the rewards of their intellectual achievements, the patent generally offers them scant protection. In most cases, the patent is awarded to an individual or a group of individuals, and the corporation that employs these individuals owns the patent. Further, the argument that "we have enough engineers..." as justification for perpetuating these policies represents the sort of myopia that leads to the formation of trade unions. Jack's assessment of the singular capabilities of Michael Jackson, Steven Spielberg, and Bill Cosby ignores all the equally talented performers whose contributions we've yet to realize. Finally, our entire discussion relates to creative contribution. Without minimizing the contributions of janitors, secretaries, or technicians, we are not suggesting the distribution of royalties to the support staff any more than we'd encourage Michael Jackson to give his stage crew a cut from the gate receipts.)

He'd like to program "customized" pauses

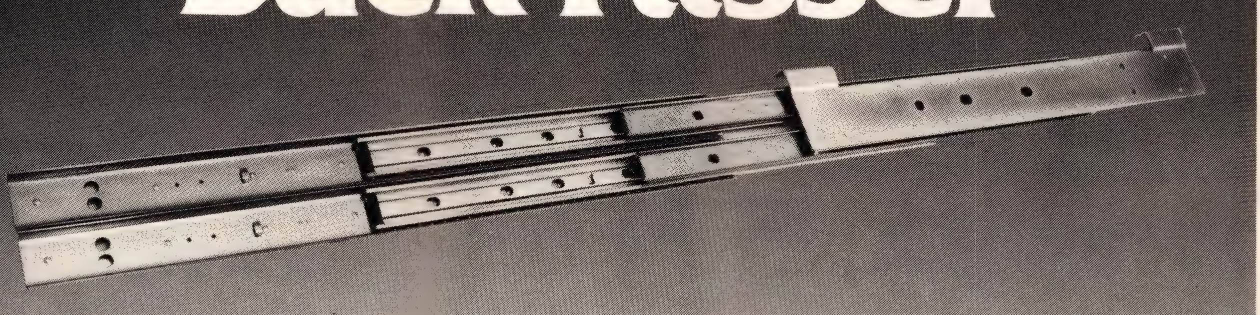
As a musician and radio amateur, I use a variety of μP-based consumer electronic equipment. Such equipment usually makes provisions for some type of delays in programmed sequences. These provisions, however, never quite meet my desires, primarily because I have changing needs. I've written to various vendors and consumer-oriented publications, but have yet to receive a reply.

I believe that other engineers who design such equipment will understand my desires better than their marketing organizations, and I hope this letter will help me reach them.

I am assuming that the particular equipment has a numeric keypad or other provision for numeric entries. In this case, I'd prefer delays that I can program. For example, when I listen to recorded music on tape, CD, or disk, I'd like to have a pause between selections. The length of the pause would vary from a couple of seconds for popular material to perhaps 30 sec between movements of classical works to as much as several minutes between entire classical works.

Ideally, I'd like to program a pause of my choosing between each program choice. As a compromise, I'd settle for pauses with a common duration, as long as I can set the duration to suit the type of music. (I'd use programmed pauses between movements of classical works

"Buck Passer"



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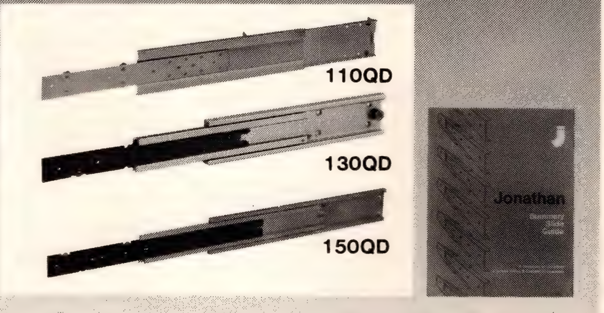

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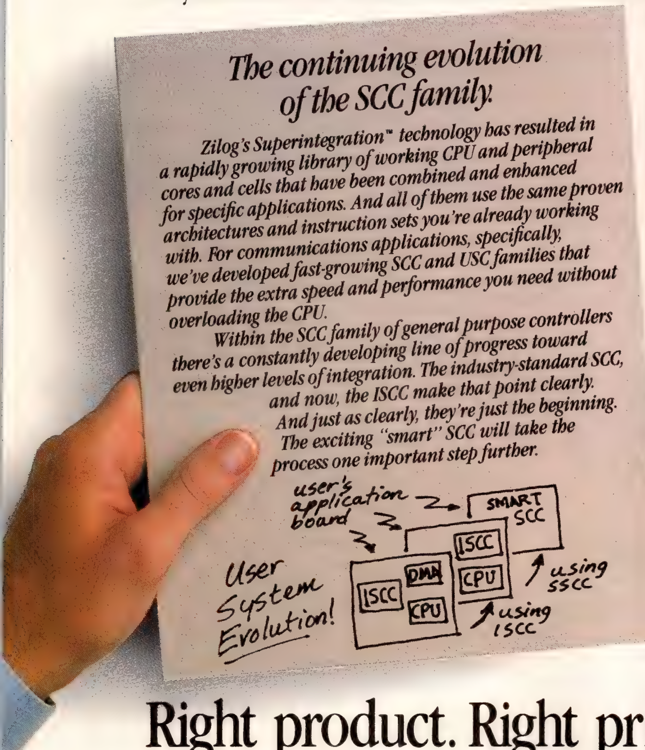
The ISCC is designed for applications that don't require the higher bit rates of the USC, but do require DMA interface to larger memory systems as found in networked small computers, for example. In fact, it's the only integrated general purpose alternative available. It's also off the shelf. And backed by Zilog's proven quality and reliability. To find out more about the ISCC or any of Zilog's rapidly growing family of Superintegration products, contact your local Zilog sales office or your authorized distributor today. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.



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CIRCLE NO. 27

and start each work manually in this scenario.)

As another example, I have several radios with scan capability. Each provides for pauses. None allows me to program a pause of my choosing on a channel that's active plus another pause of my choosing if the active channel goes inactive (to allow another user to respond to the first transmission before resuming scan).

In each case, there are times when pauses should be as short as 1 sec, or as long as infinity (or until the user intervenes). Again, these pauses would ideally be programmable channel by channel, but pauses with a common programmable duration would be a tremendous improvement over what is available.

Robert G Huenemann, MSEE
W6RFW
Hollister, CA

Double-edged sword awaits phone users

Although the technology involved in ANI (automatic number identification) is marvelous and interesting (EDN, January 4, 1990, pg 43), it may have a double-edged sword waiting for us.

Knowing the telephone number of a caller may indeed give all of us on the other end of the line a bit more privacy and is indeed an interesting use of technology, but what about the privacy of the caller? If you have paid a fee for an unlisted or unpublished number, does using the phone obviate that service by supplying the party you are calling with your number? Does every call you make to a business automatically place you in a database for later calls or mailings?

I am personally a bit of a technology junky. However, new technologies can have a darker side, and I think we all ought to look before we leap.

John W Lydic Jr
Senior Engineer,
Hardware Systems
Industrial Data Technologies
Westerville, OH

Corrections

An incorrect address for Deutsch Research (a manufacturer of Macintosh-based design tools) appears on pg 145 of the March 1, 1990, issue of EDN. The correct address reads as follows: 761 DeSoto Dr, Palo Alto, CA 94303.

On the same page, the street number for Doctor Design should read 5415 Oberlin Dr.

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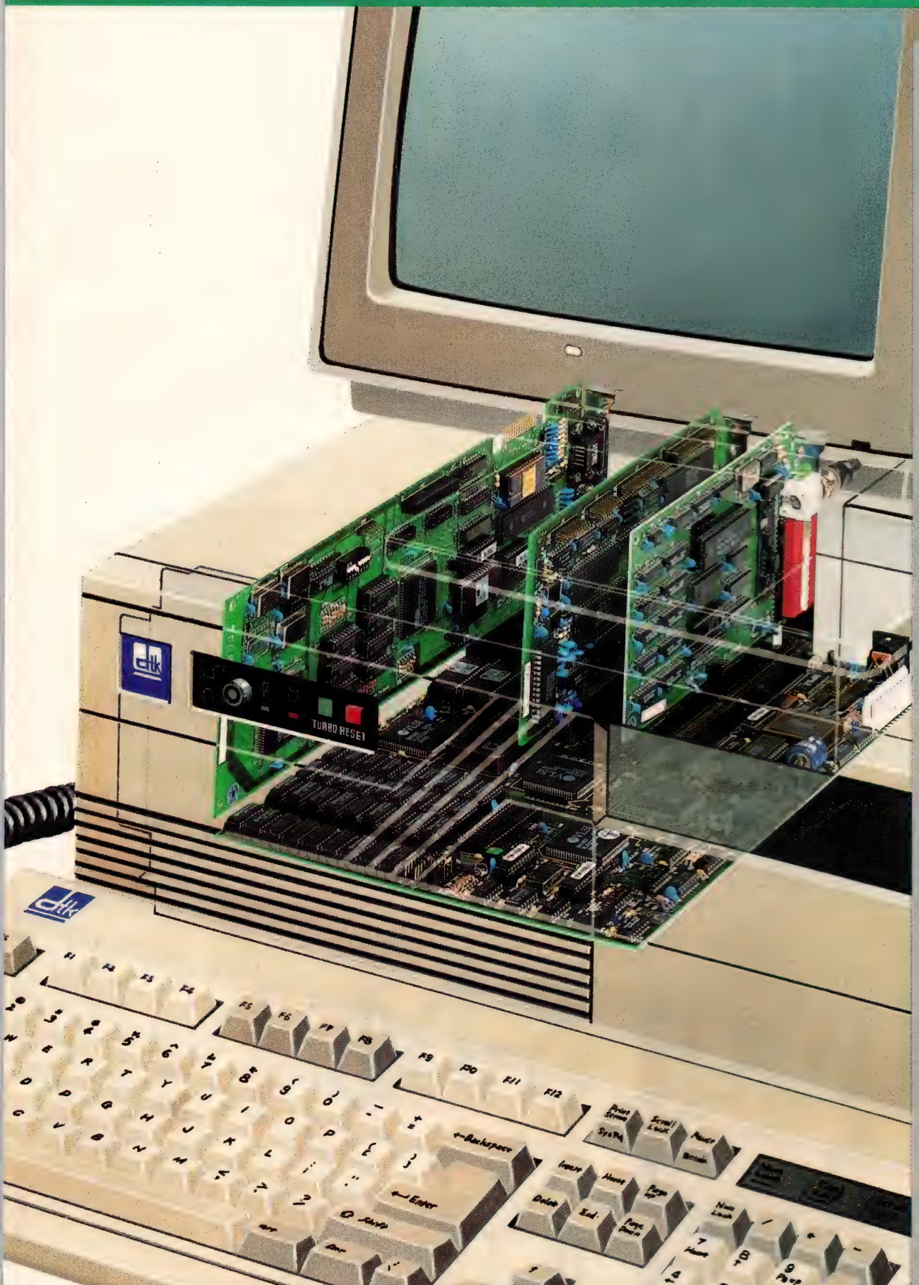

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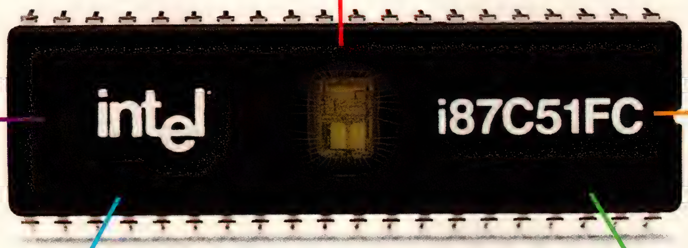

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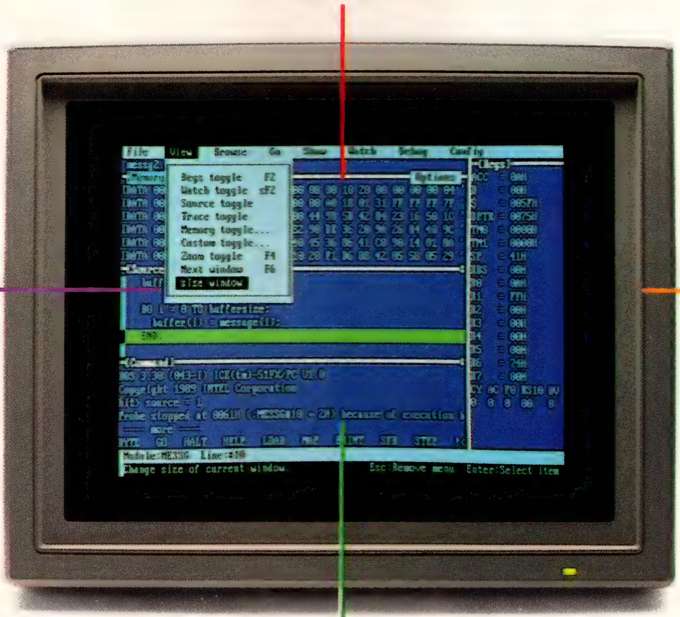

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286/16MHz	32K, 64K	Up to 8Mb	CAT940/16
286/16MHz	-	Up to 2Mb	CAT900/16
286/10MHz	-	Up to 2Mb	CAT900/10
286/8MHz	-	Up to 2Mb	CAT900/8
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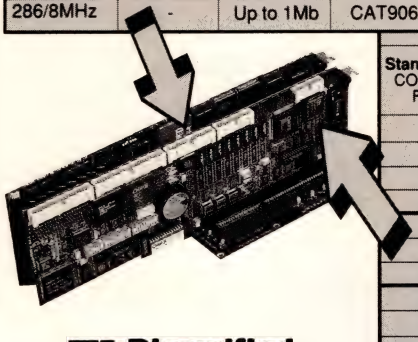

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CALENDAR

EMC Design and EMI Mitigation (short course), East Brunswick, NJ. The Center for Professional Advancement, Box 964, East Brunswick, NJ 08816. (201) 613-4500. FAX (201) 238-9113. April 30 to May 2.

Integrated Circuit Manufacturing Technology (short course), San Francisco, CA. The Center for Professional Advancement, Box 964, East Brunswick, NJ 08816. (201) 613-4500. FAX (201) 238-9113. April 30 to May 2.

Commercially Available Single-Chip Digital Signal Processors (conference), Cambridge, MA. DSP Associates, 18 Peregrine Rd, Newton, MA 02159. (617) 964-3817. FAX (617) 969-6689. April 30 to May 3.

Structured Development Forum XI, San Diego, CA. Computer Sciences Corp, 1321 Mercedes Dr, Hanover, MD 21076. (301) 859-0400. April 30 to May 3.

Use of PCs for Electronic Circuit Design (short course), East Brunswick, NJ. The Center for Professional Advancement, Box 964, East Brunswick, NJ 08816. (201) 613-4500. FAX (201) 238-9113. April 30 to May 3.

EMC Measurements, Test Facilities, Instrumentation, and Errors (short course), East Brunswick, NJ. The Center for Professional Advancement, Box 964, East Brunswick, NJ 08816. (201) 613-4500. FAX (201) 238-9113. May 3 to 4.

8th IEMT 1990 International Electronic Manufacturing Technology Symposium, Baveno, Italy. IEMT 1990 Secretariat, Box 210, 27100 Pavia, Italy. +39 382-28060-302857. FAX +39 382 27697. May 7 to 9.

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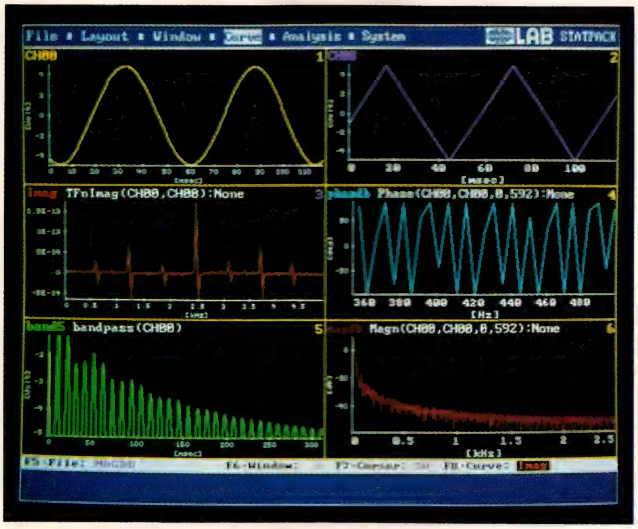

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CIRCLE NO. 29

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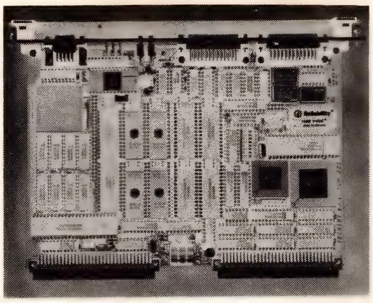

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CIRCLE NO. 35

CALENDAR

1990 IEEE AP-S International Symposium and URSI Radio Science Meeting, Dallas, TX. Dr Shashi Sanzgiri, General Chairman, IEEE AP-S/URSI Symposium, Box 860130, Plano, TX 75086. (214) 952-3772. FAX (214) 952-3085. May 7 to 11.

Surface Mount/Fine Pitch Design and Manufacturing Techniques (short course), Sunnyvale, CA. PPM Associates, Box 700039, San Jose, CA 95170. (408) 996-9765. FAX (408) 996-9765. May 8 to 9.

DEXPO South 90—The National DEC Computing and Connectivity Exposition, New Orleans, LA. Expoconsul International Inc, 3 Independence Way, Princeton, NJ 08540. (609) 987-9400. May 8 to 10.

Components Engineering, Reliability, and Test Conference, Crawley, England. Electronic Components Institute Internationale Inc, 1 Rockington Way, Crowborough, East Sussex TN6 2NJ, England. 44-892-655581. May 9 to 11.

Electro/90 Technical Conference and Exposition, Boston, MA. Electronic Conventions Management, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. May 9 to 11.

The Monterey Software Conference—Software Development in the 1990s, Monterey, CA. The Ken Orr Institute, 5875 SW 29th St, Topeka, KS 66614. (913) 273-0653. FAX (913) 273-2542. May 9 to 11.

Custom Integrated Circuits Conference 1990, Boston, MA. Roberta Kaspar, Technical Program Coordinator, CICC, 1597 Ridge Rd W, Suite 101C, Rochester, NY 14615. (716) 865-7164. FAX (716) 865-2639. May 13 to 16.

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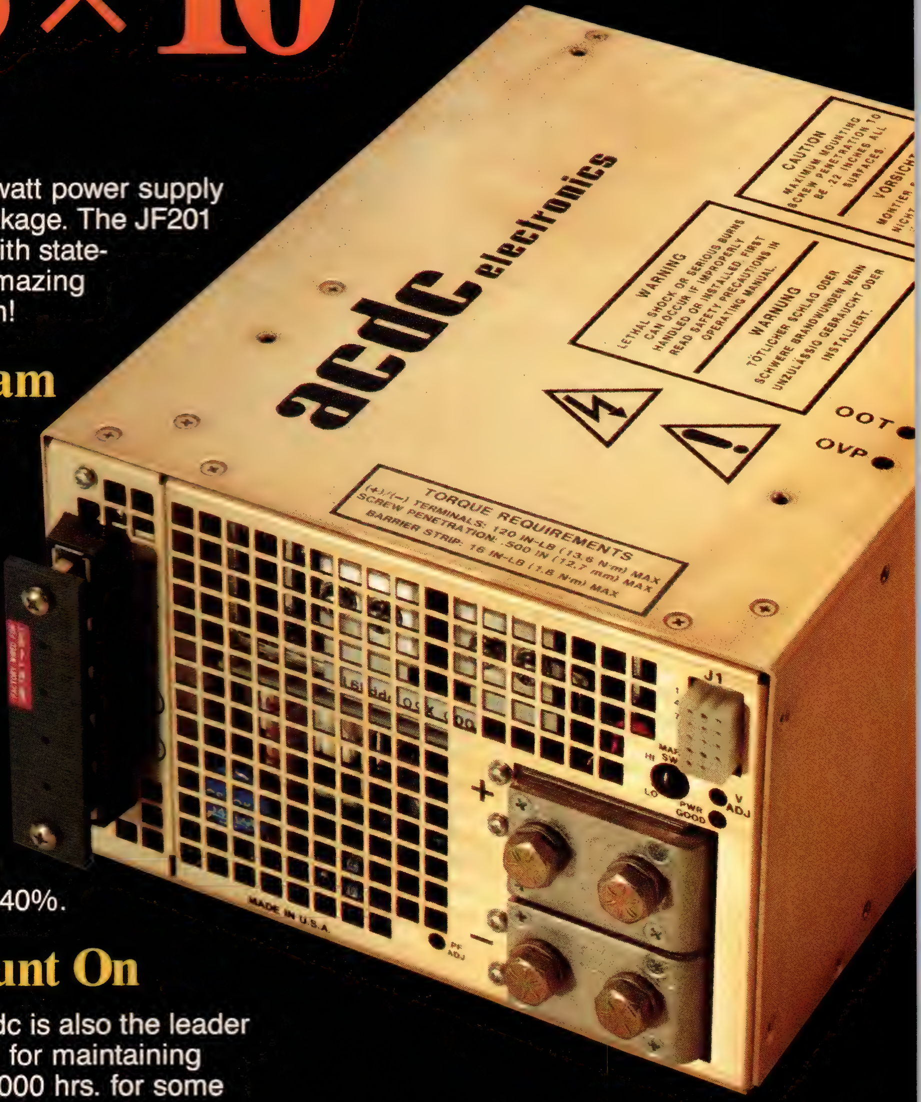
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MECHANICAL SHOCK	1.5Kg's, 0.5μsec pulse	883, Method 2002
VIBRATION	variable frequency 20 to 2,000 Hz	750, Method 2056
TEMPERATURE CYCLE	-65°C to +125°C 200 cycles, 10 min. dwell	883, Method 1010
AUTOCLAVE (pressure pot)	14.7psi, T_A +121°C, 96 hr.	H-P GSS, 09-109
85/85	85°C @ 85% humidity 168 hr., no bias	H-P GSS, 09-107B
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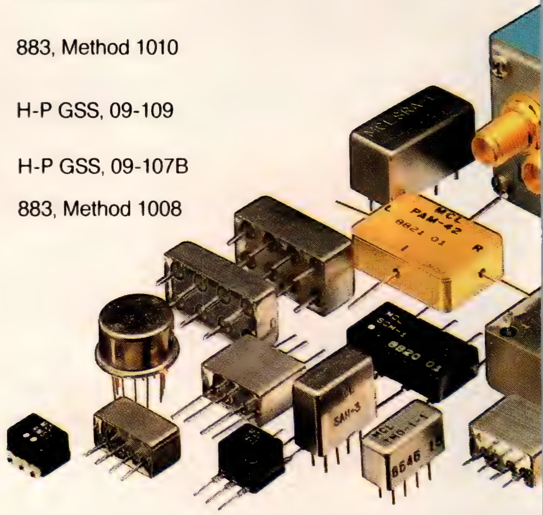

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F130-2 REV. A

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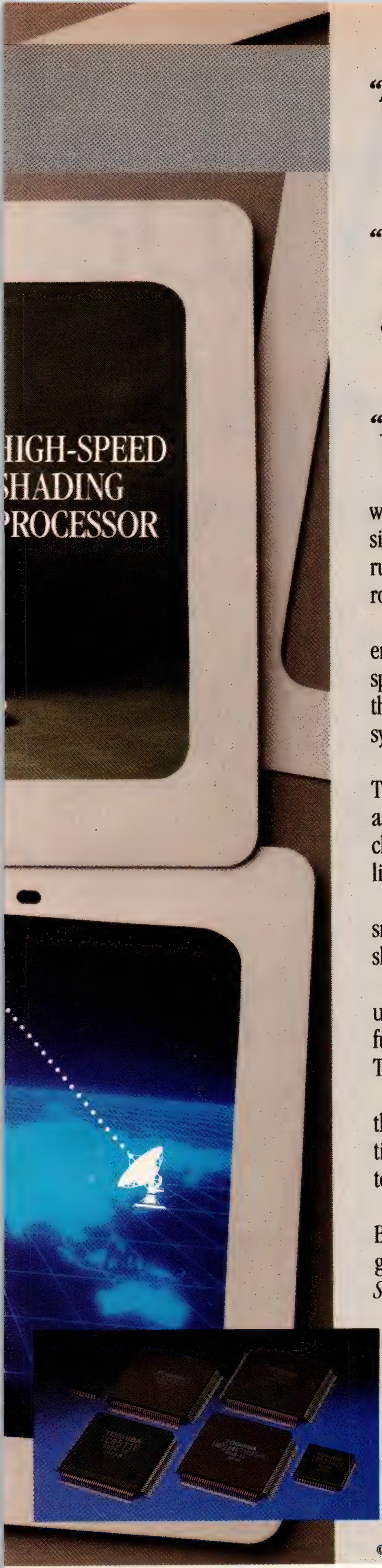

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"A full line of embedded controllers for our integrated systems, which means we can drop man-years of software development."

"You mean we can do it all with hardware, and achieve orders of magnitude greater performance?"

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It's true. With Toshiba's highly integrated line of embedded controllers, you won't have to rely on slow, memory-hungry software routines any more. Instead, a single embedded chip implements complex algorithms. The result—a system running at least an order of magnitude faster than even optimized software routines.

This advanced line-up of embedded controllers is a product of Toshiba's leadership in CMOS technology. Each offers a single chip embedded solution to a specific application. All provide significant advantages in system speed and throughput over other products on the market. And they provide a higher level of system integration.

If you're designing laser or print-shop quality printing systems, for instance, the TC8511F Font Graphics Accelerator (FGA) provides the full set of font rasterizing algorithms. For everything from common fonts to the most demanding graphics characters. Rasterizing is conducted with algorithms for Bezier curves, straight lines, arcs and ellipses.

The High-speed Shading Processor (HSP), on the other hand, provides for the smooth shading of 3-D or 2-D graphic displays. The solution is based on a Gouraud shading procedure, and is intended especially for PC and workstation displays.

The Token Ring Controller (TRC) is an IEEE 802.5 based LAN controller utilizing token ring protocol. It also includes MAC operations, supports bridge functions, and is 16/4 Mbps software switchable as well. The TRC operates with a Toshiba BiCMOS media driver.

For international standard communications, the ISDN protocol controller meets the CCITT basic rate interface recommendations. It is suitable for broad applications such as digital telephone, facsimile, terminal adapter and other ISDN terminals.

There's a good deal more to tell you about these advanced embedded controllers. But we just don't have the room. If you'd like technical literature for any of them, give us a call at 1-800-888-0848, ext. 517. We'll fill in whatever details you need. *Service is our key component.*

In Touch with Tomorrow

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CIRCLE NO. 39

EDITORIAL

Communication technologies: bringing the industry back

Most members of the electronics industry realize that business is off. As I meet with people, the inevitable question they ask is, "What will bring the industry back?" We give our nod to communication technologies, the field that we think has the best chance of pulling the electronics industry out of the slump, probably late this year.

Don't look to computer technology to push us out of the doldrums. IBM, Digital Equipment Corp, Sun Microsystems, and others are having problems of their own. Still other computer companies are going through restructurings, layoffs, and mergers. Also, many computer users have enough computer power on their desks to last several years. They're waiting for the software to catch up. They're also waiting for sophisticated communication links with other people and their computers. The future belongs not to the "power users" who know every intricacy of spreadsheets and databases, but to the "power communicators" who know how and where to get important information.

If you're in doubt about the forces driving the push for more and better communications, check the business section of your Sunday newspaper. Look at the advertisements that promote specialized telephone equipment, answering systems, and facsimile machines. My daughter thinks that our family should have a fax machine at home so that she can exchange notes and homework with her friends. At the rate that fax prices are dropping, she may not have long to wait. The demand for home fax machines may dwarf yesterday's demand for home computers. In fact, shipments of fax add-in boards for PCs alone could reach 500,000 units by 1992.

The coming wave of communication devices and applications doesn't end with fax machines. Consider all of the document scanners, multimedia systems, and TV-image-compression and -transmission systems that are already on the market or will be soon. The next decade will bring a surge of new activity in the Integrated Services Digital Network (ISDN) and in the use of fiber-distributed-data-interface (FDDI) networks. As promising as ISDN is, don't be surprised to see even newer communication technologies come to the fore. Many power communicators will want the instant access and high bandwidth of fiber optics.

The future promises explosive growth in cellular communications, too. Hewlett-Packard expects the radio-frequency communication business to grow from today's $9 billion to between $50 and $150 billion in 10 years. One reason: digital cellular phones.

Let's keep this communications explosion in perspective. Most of the communication technologies are already here, so it may seem like communications is really no big deal. It is. There are advances and breakthroughs waiting to be made, and as always, it's up to you and other innovators to put these technologies to work for the rest of us. The next few years should be exciting ones for those of you with a vision of the future of communications and an innovative and entrepreneurial bent. We're depending on you.

See us at Electro

If you're headed to Electro, stop by the EDN booth and talk with one of our editors about technology, future directions, and what you'd like more or less of in EDN. We'll be standing by between 1 and 5 PM on May 9 and 10.

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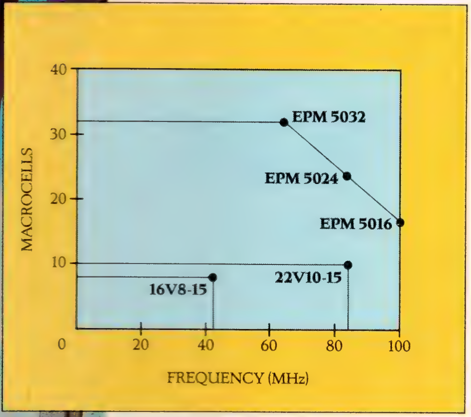

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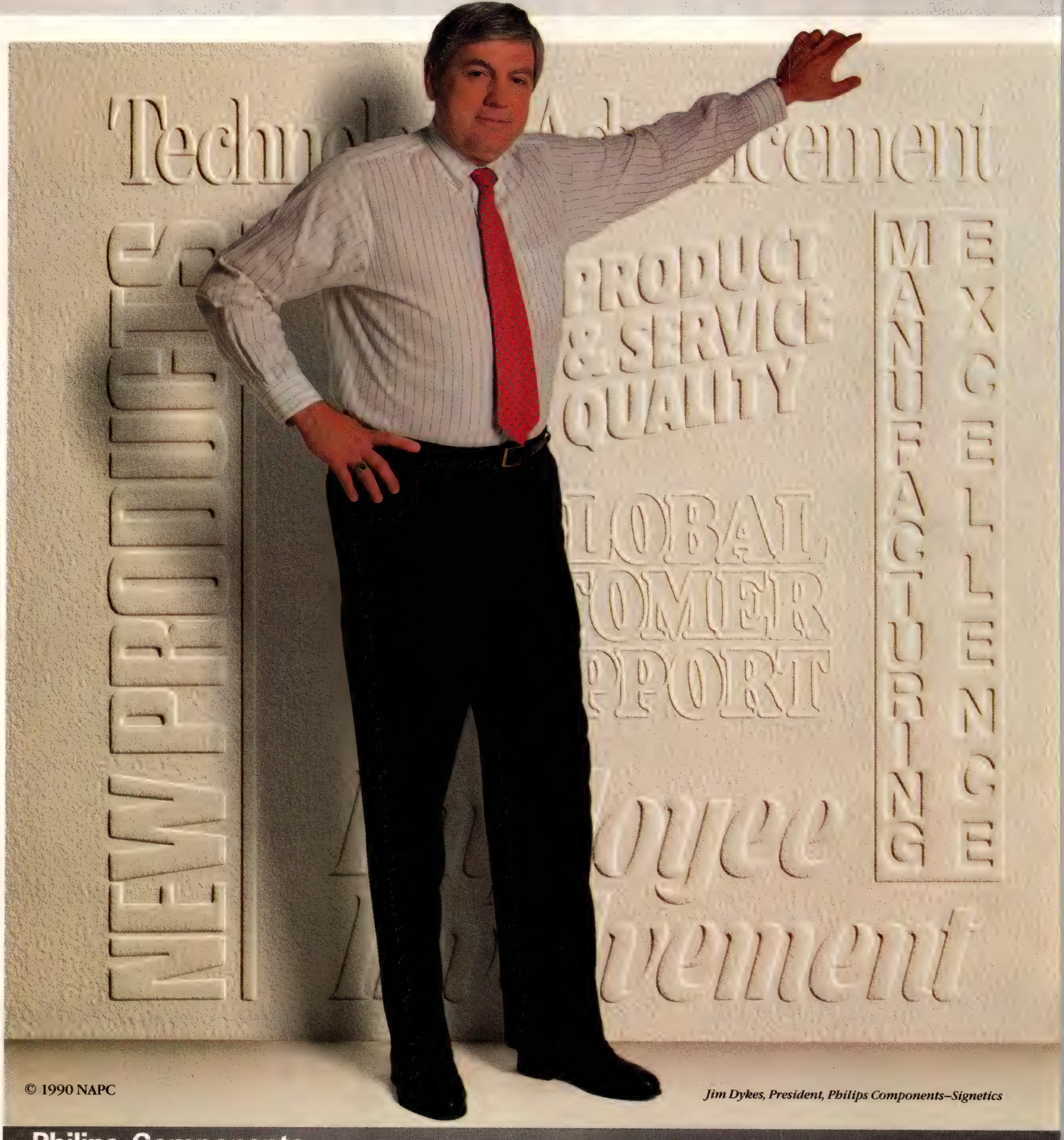
CIRCLE NO. 55

“These are the dimension all IC manufacturers



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Jim Dykes, President, Philips Components–Signetics

Philips Components

# of performance by which vill be measured.”

JIM DYKES ON MAKING THE PREFERRED LIST.

As IC markets advance into the ’90s, benchmarks are shifting from speed and specs to new global criteria. Customers are narrowing their suppliers to a few key partners who excel in six essential areas. Here’s how Signetics is responding to these six “dimensions of performance.”

TECHNOLOGY ADVANCEMENTS. We’re working with our customers to push the boundaries of tomorrow’s technologies. That includes innovations in Bipolar, CMOS and BiCMOS, as well as in our leading-edge surface mount technology. It also includes strategic partnerships to apply technologies like Sun Microsystems’ SPARC™ to many new products.

NEW PRODUCTS. We’re listening to customer feedback and responding to the need for products like high-performance, lower power ICs, and for application-specific products. Good examples are our cellular phone chip set, fiber optics chip set and 42VA12 sequencer, each voted “Best of ’89” by *Electronic Design.* Cycle time management speeds our design time and gets innovations to market fast.

GLOBAL CUSTOMER SUPPORT. Customers need immediate answers. They can get them through the Philips network of sales offices and design centers in 65 countries around the world. From design-in and sales to application support, our customers find local responsiveness in every major market. We continue pushing improvements in every area of support, from EDI for order placement and forecasts to JIT deliveries.

PRODUCT AND SERVICE QUALITY. Today, how a service team performs is as important as how a product performs. We’re addressing this critical issue with cycle time management to speed our delivery and our response to special requests. We’ve established ship-to-stock and critical process change notice programs that our customers say are the best. And now, Signetics has adopted the Baldrige Award criteria as our standard.

MANUFACTURING EXCELLENCE. In production there’s no room for compromise. We’re meeting demanding standards with proven facilities and experienced fabrication and assembly teams throughout the world. With cycle time management and advanced statistical process control methods, shipment after shipment of the products we turn out are of world-class quality.

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EXTENDING THE DIMENSIONS OF PERFORMANCE

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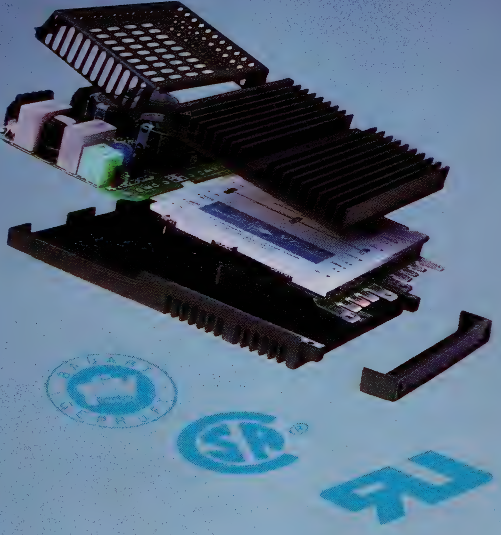
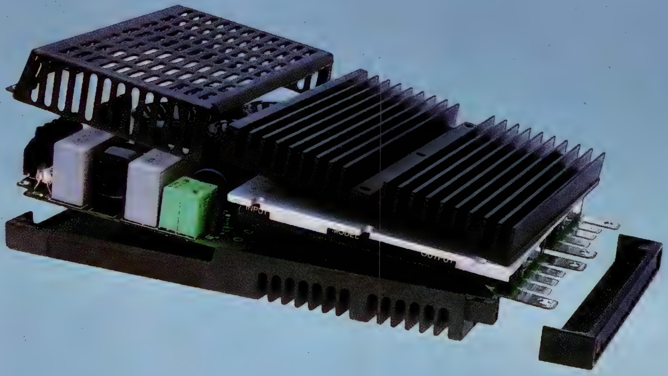




Celebrating The New Profile

Introducing the FlatPAC™... Vicor's Family of User Definable, Multiple Output, Switching Power Supplies

Until now, your power system decision meant choosing between costly and unpredictable custom development, or bulky and inflexible catalog supplies...or you had to design and manufacture it yourself. Taking the next step in the power-component revolution, Vicor introduces FlatPAC, the user-definable, "off-the-shelf" alternative to customs that's economical from single units to OEM quantities...and which fits in a fraction of the space required by conventional off-line supplies!

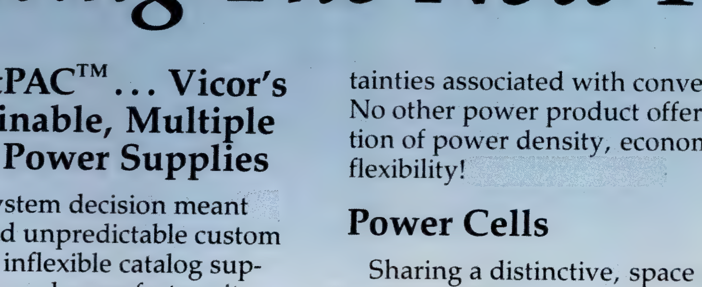
The Off-The-Shelf Alternative

FlatPAC's unique modular design allows Vicor to provide next day delivery on over 10,000 different FlatPAC configurations. You define your power requirements... Vicor does the rest – while eliminating the non-recurring costs, unpredictable lead times, risk, inflexibility, and reliability uncertainties associated with conventional solutions. No other power product offers FlatPAC's combination of power density, economy, and "off-the-shelf" flexibility!

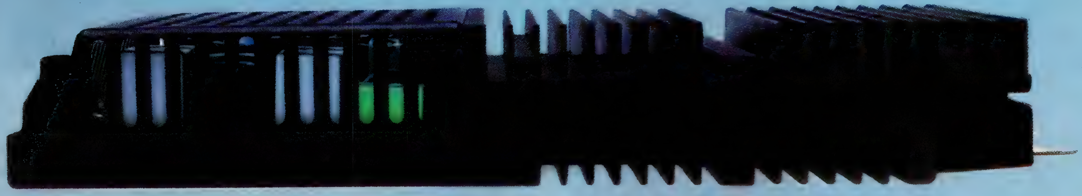
Power Cells

Sharing a distinctive, space saving flat package profile (1.37" high x 8.6" long), FlatPACs come in widths of 2.5", 4.9", and 7.4", and supply up to 200, 400, and 600 Watts of total output power...an unprecedented 7 Watts per cubic inch in an off-line switching power supply!

The three different packages provide one, two, or three user definable "Power Cells". Each Power Cell may be specified to be an independent, isolated output with a power rating of 50, 75, 100, 150, or 200 Watts, or cells may be combined to form higher power outputs...up to 600 Watts from a single output. Standard output voltages are 5, 12, 15, 24, and 48 Volts – and because all FlatPAC outputs are field trimmable down to zero and up to 110% of nominal, a standard output can likely



FLATPAC



In Off-Line Switchers.

take care of even your most unusual voltage requirements. For special requirements, outputs as low as 2 Volts, and as high as 95 Volts can be provided.

And you don't give up features to get FlatPAC's advantages: besides being trimmable, all FlatPAC outputs have remote sensing and overvoltage and overcurrent protection. Individual FlatPAC outputs are totally isolated: there are no cross regulation issues; any output can be positive or negative; and output returns can float up to 500V, rms, apart. FlatPAC's run on either 110 or 220 Volt lines, meet "Class A" interference specs, have built in fusing, and conform to UL, CSA, and TUV safety agency requirements. Two and three cell units also provide two isolated, sequenced, logic outputs to indicate pending loss-of-line and pending loss-of-output for system housekeeping during power cycling or brownouts.

The key to FlatPAC's flexibility and power density is Vicor's VI-200 family of high density, high efficiency, UL, CSA, and TUV recognized, component level DC-DC converters. When you specify a FlatPAC, you benefit from the field reliability and predictability that's been established in an installed base approaching half a million units.

Join The Celebration Now

Call Vicor now to discuss your special needs...you'll be celebrating when you find how quickly Vicor can ship you the smallest, most efficient, most cost effective solution to your power system requirements...at prices as low as 85¢/Watt in OEM quantities.

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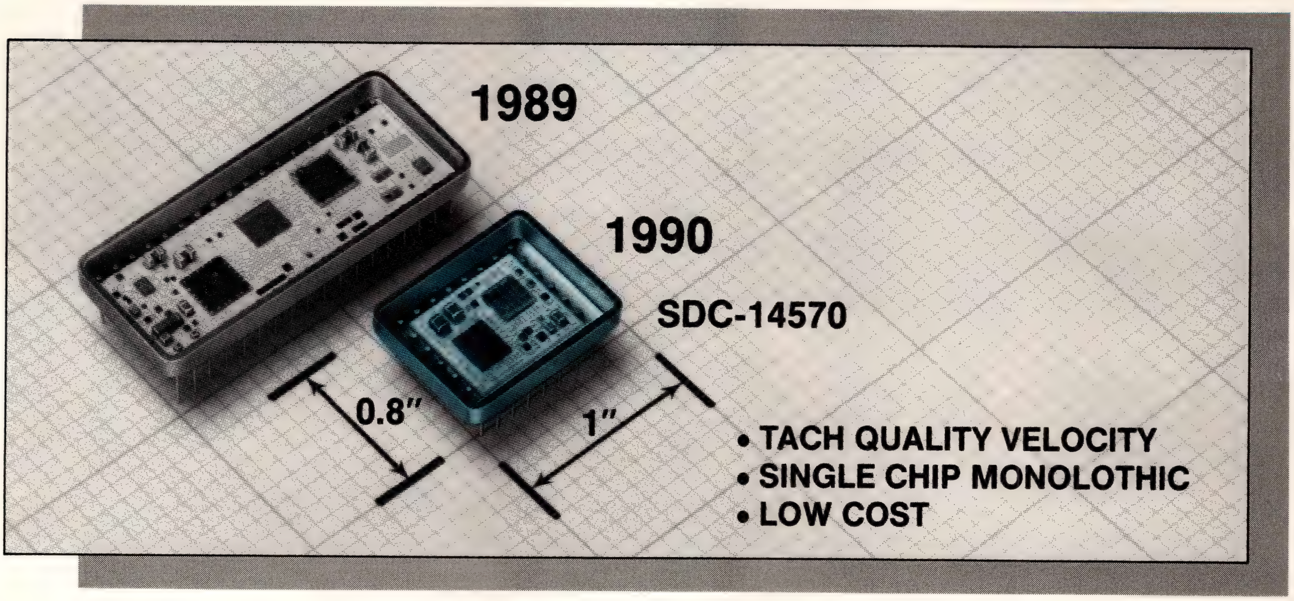

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- LOW COST

DDC is pleased to announce the second in a family of next generation tracking synchro- or resolver-to-digital converters. The new SDC-14570 Series is based upon a proprietary single-chip R/D converter and is by far the smallest available converter of its type. Offering 14-bit resolution and input scaling for synchro or resolver signals, this converter series is packaged in a very small 0.8″ x 1.0″ hermetic hybrid. The SDC-14570 Series converters provide a tachometer quality velocity output signal, as well as a Built-In-Test ($\overline{\text{BIT}}$) output.

The SDC-14570 Series is a type II tracking converter providing an accuracy of 4 minutes. It is insensitive to noisy signals as well as variations in signal level, reference frequency, harmonic distortion, and power supply voltage. Available input options are 11.8 volt resolver, 11.8 volt or 90 volt synchro, or 2 volt direct resolver. Input frequency range is 360Hz to 5kHz and closed loop bandwidth is 100Hz.

The velocity output signal is quite useful in position control servo loops and may be used to replace a tachometer's stabilizing velocity feedback. Digital outputs of the SDC-14570 Series are buffered with a tri-state transparent latch and data may be transferred without disturbing the converter's tracking of input signals.

With its –55° C to +125° C operating temperature range and MIL-STD-883 screening, the SDC-14570 Series achieves the best size/performance/price for military converters in today's market. Typical applications include radar antenna positioning, inertial platforms, and systems (flight control, fire control, and navigation).

With its reliable monolithic design, small hermetic package, wide operating temperature range, and flexible high performance, the SDC-14570 Series is ideal for the most demanding military applications. **For more information or applications assistance, call Bill Cullum at 516-563-5678 or contact the DDC office nearest you.** ☐

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PANEL-MOUNT OPTICAL ENCODERS

Long-lived devices offer high resolution

Throughout their extensive lifetimes, panel-mount optical encoders provide high resolution for manual input controls.

Doug Conner,
Regional Editor

Panel-mount optical encoders are a reliable alternative to contact devices such as rotary switches and variable-resistance potentiometers. For these contact devices, a long lifetime is about 100,000 to 300,000 revolutions, whereas the *shortest* lifetime for an optical encoder is 1 million revolutions.

An optical encoder's lifetime is limited by the life of its mechanical bearings and depends on the shaft's radial and axial loads and the type of bearings. If you need an encoder with a longer life, some manufacturers can upgrade their products with ball bearings to provide 100 million or more revolutions.

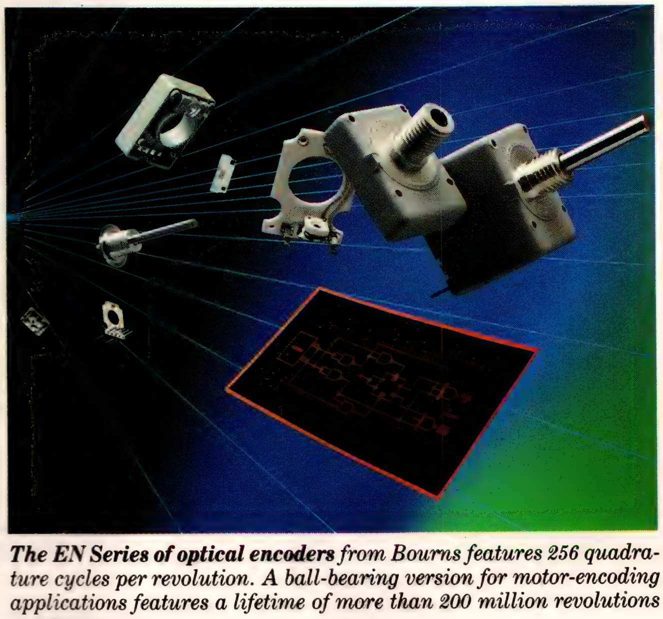
Panel-mount optical encoders may have longevity, but their prices are high. Typically, these devices cost from \$10 to \$25 (1000), as **Table 1** shows. In contrast, contact switches start at less than \$1 (1000).

Nevertheless, panel-mount optical encoders have certain benefits that are tough to assign a dollar value to—for example, the "feel" of the bearings. A product's "feel" is simply the quality you perceive by handling the controls. This subjective test is important to any user.

In an optical encoder, the shaft bearings are the only source of friction, so the encoder may produce very little friction. To provide the best frictional feel for the bearings, manufacturers select appropriate bushing materials. The rotational feel of these bushings changes very little over the product's life. In potentiometers, on the other hand, the wipers tend to wear down over time, changing the feel of the device.

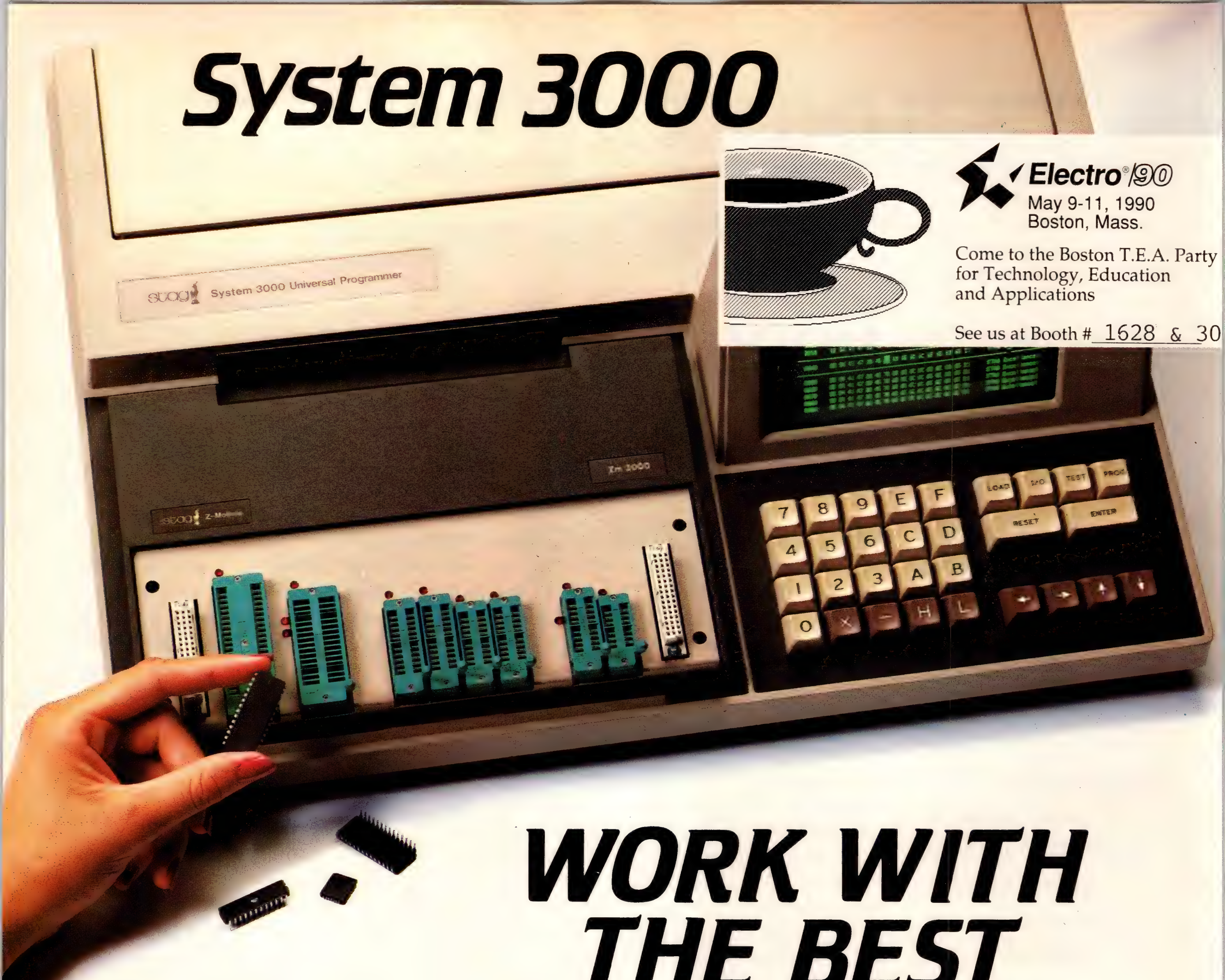
Some optical encoders have detents that provide positive positioning and less sensitivity to vibration. Many encoders that are designed for machine tools, aircraft, and other high-vibration environments feature detents. No friction from electrical contacts is present, so the detent action can be light; as a result, the shaft is easy to rotate and insensitive to vibration.

The HEDS-5700 Series from Hewlett-Packard features 512 quadrature cycles per revolution, and a variety of ven-



The EN Series of optical encoders *from Bourns features 256 quadrature cycles per revolution. A ball-bearing version for motor-encoding applications features a lifetime of more than 200 million revolutions at 5000 rpm.*

System 3000



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The System 3000 is designed to program PROMS, PLD's and Microcomputers in every known technology. The technology includes NMOS, CMOS, ECL, Fuse Link, AIM, DEAP and Isoplanar-Z. Surface mount devices can be programmed on an optional SMD chip-station.

Users can easily install the innovative 'Smart' Card to update new Device Support Libraries in seconds.

Built-In CRT
The System 3000 incorporates its own CRT display and keyboard allowing it to be used as a powerful stand-alone programmer. On-screen menus and prompts allow device selection and all system operation functions to be easily executed.

The System 3000 also gives you full-screen editing of both memory and logic data including test vectors. Light pen operation and custom Z-packs for life cycle testing and other specialized functions set the System 3000 apart from any other Universal Programmer.

Interface Flexibility
Four separate user interface ports, including two RS232C's, an IEEE 488 and a Handler Port, give the System 3000 unrivaled flexibility for communicating with peripheral equipment.

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CIRCLE NO. 58

Stand-Alone or Computer Operation
All stand-alone functions are operational under remote control using either a mainframe or a personal computer.

Instant Update Using a Memory Card
A unique feature of the System 3000 is that all device libraries and programming algorithms are contained on a Memory Card that can be changed instantly by the user as new devices become available. Data access is considerably faster than floppy disk-based systems.

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stag

Sophisticated systems for the discerning engineer dors offer 256 quadrature cycles per revolution on their encoders (**Table 1**). Contact devices offer much lower resolution; 24 positions is a high resolution for a contact encoder.

Avoid bit switching

Theoretically, you could obtain high resolution from an analog potentiometer; in practice, however, analog potentiometers coupled with A/D converters suffer from bit switching when you position the shaft at a bit-transition point. In this event, even ordinary fluctuations in supply voltage or temperature cause the LSB to randomly switch, a situation that's analogous to a digital voltmeter that's measuring 5V and frequently switches to 4.999V.

***The HRPG Series encoders** from Hewlett-Packard have resolutions as high as 120 quadrature cycles per revolution and cost only $10 (1000). The HEDS 5700 encoder (center) features 512 quadrature cycles per revolution.*

Optical encoders can avoid bit switching by using a Schmitt trigger on the encoder's photodetector output to provide hysteresis on the threshold determination. Some optical encoders, such as BEI Motion Systems' PM Series, provide hysteresis internally. On other encoders, you'll need to add the Schmitt triggers externally. Either way, the hysteresis is sufficient to avoid bit switching in all but extreme conditions of temperature, electrical noise, and supply-voltage fluctuations.

On both contact and noncontact switches, detents can avoid bit switching, but to avoid multiple pulses at each state transition, optical encoders still require hysteresis. Contact switches such as contact encoders may require debouncing circuitry if the application is sensitive to multiple transitions.

Optical encoders have another advantage over analog potentiometers: as you rotate the encoder's shaft, you won't encounter a dead zone. Also, optical encoders don't develop noise over a period of time, as analog potentiometers often do.

Optical units run at high speed

Unlike contact switches and potentiometers, optical encoders can operate at much higher speeds

Table 1 — Representative panel-mount optical encoders

					Electrical specifications			Maximum dimensions				
Manufacturer	**Product family**	**Standard resolutions** (quadrature cycles per revolution)	**Detents available**	**Rotational life** (millions of revolutions)	**Supply current at 5V** (maximum mA)	**Output voltage Low**	**Output voltage High**	**Depth[1]** (inches)	**Height** (inches)	**Width** (inches)	**Price[2]** ($/1000)	**Options**
BEI Motion Systems	PM Series	64,120,128,256	No	1	60	0.35	2.4	1.13	1.55	1.1	24.50	Index
Bourns	EN Series	64,100,128,256	No	10	26	0.8	4	0.73	0.84	0.63	12	Index
Clarostat	600 Series	128	No	10	30	0.4	2.4	0.48	1.38	1.13	10.75	
	688 Series	64	No	1	30	0.4	2.4	0.56	0.5	0.5	15	Concentric shafts, dual encoders
Grayhill	Series 61	16,24	Yes	1	10	0.5	3.8	0.86	0.77	0.77	15.27	Pushbutton switch
Hewlett-Packard	HRPG	16,32,64,120	Yes	1	40	0.4	2.4	0.45	0.82	0.68	10	
	HEDS 5700	96,100,192, 200,256,360, 400,500,512	No	1 to 12	40	0.4	2.4	0.72	1.62	1.18	28	
Standard Grigsby	SG-OE1	16,24,32, 64,128,152	Yes	1	10	0.5	3.8	0.66	0.77	0.77	16	Pushbutton switch
	SG-OE1-16	16	Yes	1	10	0.5	3.8	0.9	0.77	0.77	18.50	Absolute positioning, binary or Gray code

Notes:

1. Depth measured from back of front panel
2. Least expensive panel-mount version

without contact bounce or wear problems. Most panel-mount optical encoders are rated for a continuous rotational speed of 50 to 300 rpm, but remember that the bushings or detents are the limiting factors, not the switching electronics. In fact, certain panel-mount optical encoders suit motor-driven applications and operate at 5000 rpm.

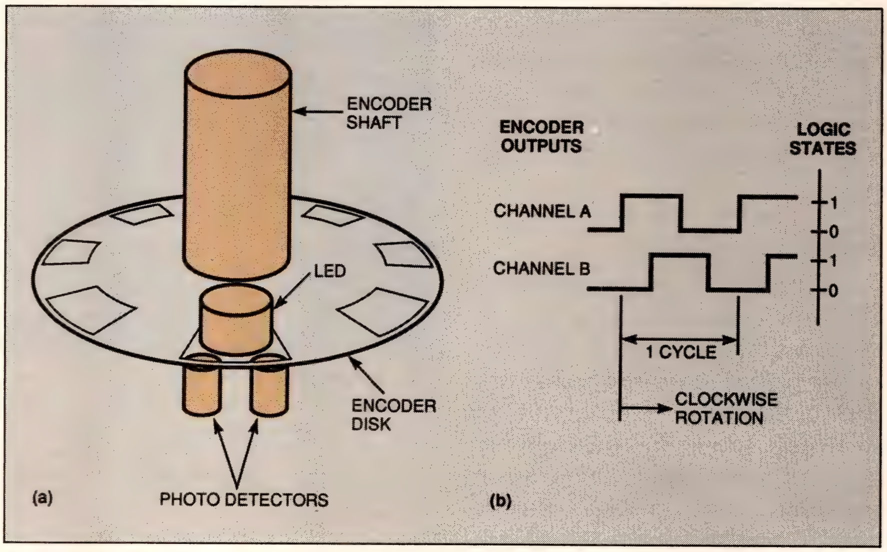


Fig 1—A typical optical-encoder design (a) *separates an LED from two photodetectors using a perforated encoding disk. The two photodetectors produce a quadrature output* ***(b)*** *that provides information about rotational direction and motion.*

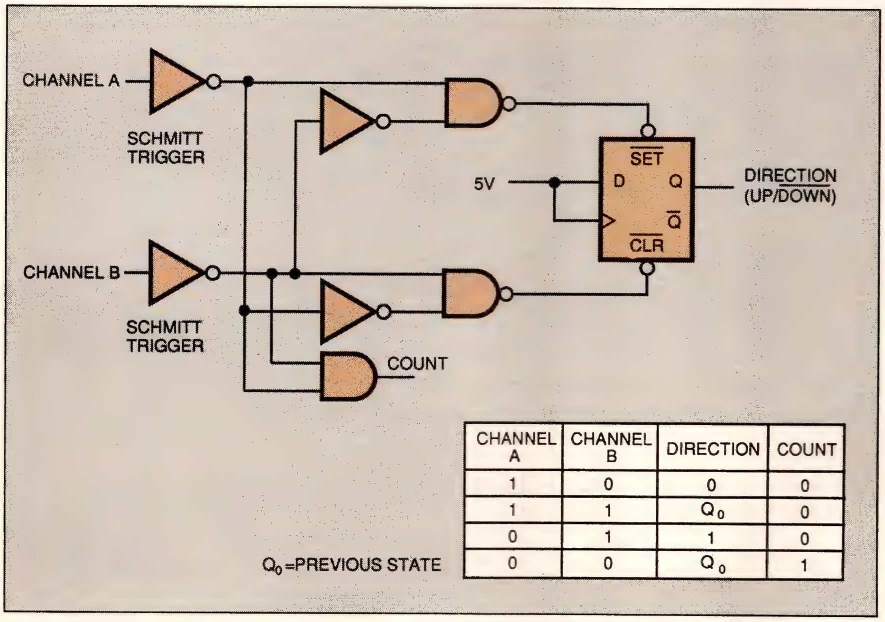
Most panel-mount optical encoders are rotary pulse generators that detect the encoder's relative position rather than its absolute position. **Fig 1** shows how a typical optical encoder works using transmission. The encoder has an LED that projects light onto a perforated disk attached to the encoder's shaft. Depending on the shaft's position, two photodetectors located on the other side of the disk receive either light or darkness. The two photodetectors provide a quadrature output that enables you to determine the shaft's direction of rotation.

Reflection is another method of determining position. The advantage of using reflection is that all of the electronics are on one chip rather than separated by the perforated disk. Putting all the electronics on one chip reduces size, cost, and temperature problems. However, if you're using the encoder in harsh environments, it will be more sensitive to dust, moisture, and oil.

Regardless of the method the encoder uses to determine the shaft's relative position, the encoder must generate pulses that increment or decrement a counter, depending on the direction of rotation. This counter can be in either hardware or software.

If you want to use the two quadrature outputs to operate a counter, you have several options. First, you can buy an IC that has the whole works on it. For example, HP offers the HCTL-2016, which includes decoding circuitry, a 16-bit counter, and an 8-bit, 3-state data interface for $5.80 (1000). An added benefit of the HCTL-2016 is that it decodes all four quadrature states in each cycle, giving you four times the nominal resolution specified for an encoder.

To drive a counter, you can also use your own decoding circuitry, as **Fig 2** shows. This circuit supplies only one pulse for each quadrature cycle, providing the encoder's nominal resolution at the output. Alternatively, if you have a microprocessor with time to burn, you could perform the decoding and counting in software.



CHANNEL A	CHANNEL B	DIRECTION	COUNT
1	0	0	0
1	1	Q_0	0
0	1	1	0
0	0	Q_0	1

Q_0=PREVIOUS STATE

Fig 2—To drive a counter, a decoding circuit *takes the two quadrature outputs* ***(Fig 1b)*** *and generates direction and count pulses. This circuit generates one count per quadrature cycle.*

An optical encoder with a single track on its encoding disk can only

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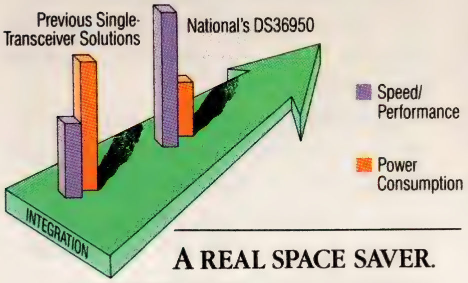

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RS-423	●	●					
3601/0	●	●			●		
MIL-188-114		●	●				
RS-422	●	●	●	●		●	●
RS-485			●	●			●
MIL (883)	●	●	●	●			●
IEEE-488							●
BTL							●

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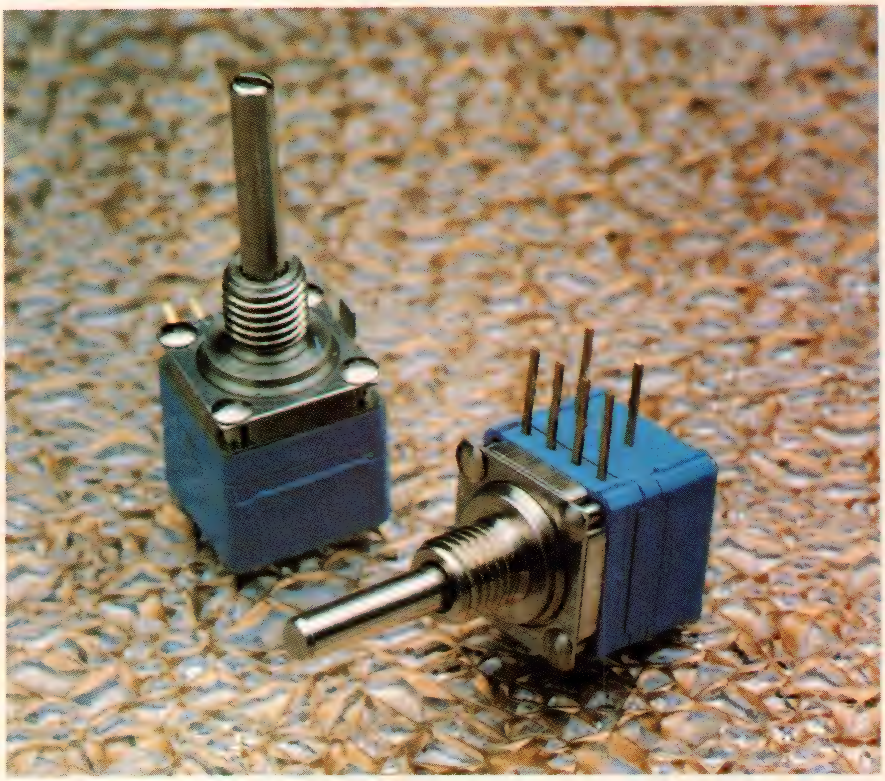

One of the smallest optical encoders available, *the Series 688 optical encoder from Clarostat is ½ in. square and 0.56 in. deep. The encoder provides as many as 64 quadrature cycles per revolution.*

determine the shaft's relative position. A single track is popular because it avoids the cost and power needed for more LEDs and photodetectors to read the additional tracks. A single track also limits the electrical connections to four wires.

Relative positioning may be an asset, a nuisance, or unacceptable, depending on your application. If you're using the encoder to control only one function and if it's the only input to that function, relative positioning could be a nuisance, because you could lose a setting in the event of a power failure.

If you're using the encoder with other input sources such as a keypad or downloading from a computer, keeping the value in a counter and using relative positioning is an asset. Relative positioning is also an asset if you're using the encoder as a software-programmable input device to control different functions at different times.

If you're using the optical encoder as a switch control—for example, a 16-position switch with indicator settings printed on the front panel of the product—absolute positioning is mandatory.

Certain optical encoders feature absolute positioning, but the ones that offer high resolution are costly. For $18.50 (1000), Standard Grigsby offers a 16-position switch that outputs 4 bits in either binary or Gray code.

In deciding on whether to use absolute or relative positioning, you may want to compromise by buying an encoder that has a second encoding track with a single index point. Using the index point and the appropriate logic, you can reset the absolute position by spinning the shaft one revolution.

Another alternative to panel-mount optical encoders are mag-

For more information . . .

For more information on the panel-mount optical encoders discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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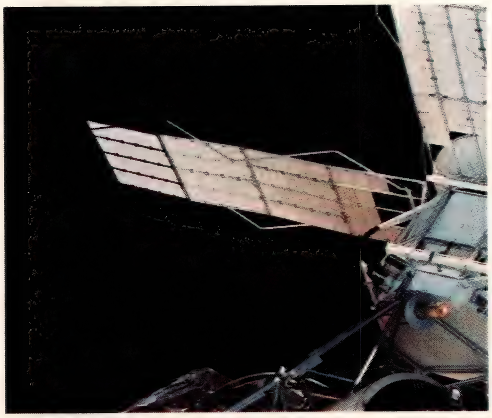

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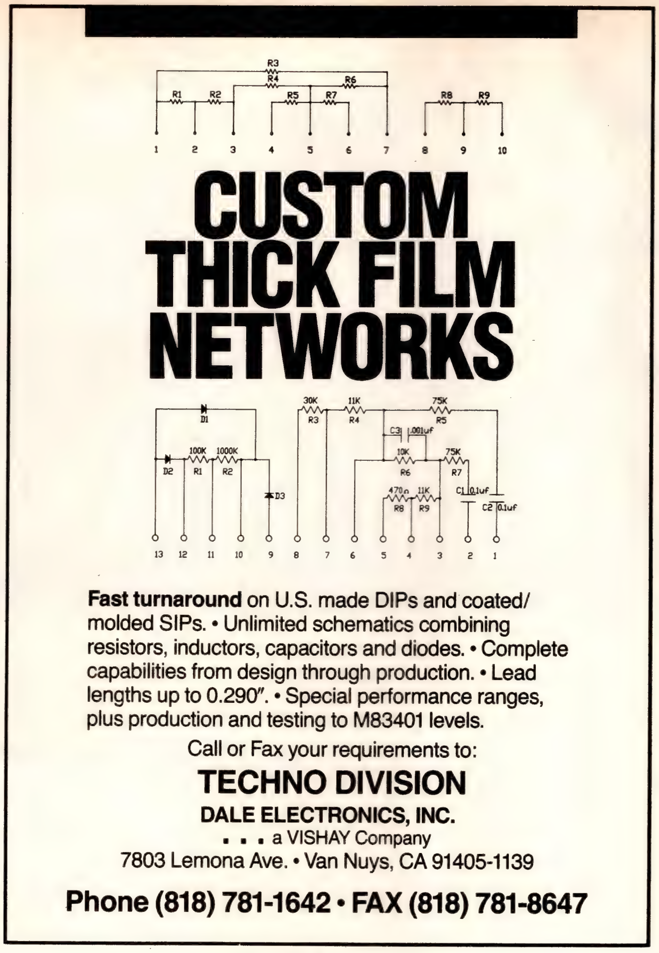

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netic encoders, which are noncontact devices. These encoders use a rotating disk magnetized with alternating poles and detect the disk's position using a Hall-effect sensor. Magnetic encoders offer advantages over optical encoders such as low power consumption and less sensitivity to moisture, oil, dust, and shock.

The greatest disadvantage of magnetic encoders is their low resolution. The best resolution available in magnetic encoders is about 16 quadrature cycles per revolution. For example, Micro Mo's (St Petersburg, FL) HEF Series encoder generates 16 quadrature cycles per revolution, consumes 5 mA at 5V, and costs $25.90 (1000). EECO (Santa Ana, CA) will also provide a 16-position magnetic encoder this year.

Competitively priced magnetic encoders probably won't approach the resolution limits of optical encoders. However, in the next few years manufacturers will considerably improve their magnetic devices, possibly offering 64 quadrature cycles per revolution. For now and the near future, however, optical encoders are your best bet for applications that require high resolution and long life. **EDN**

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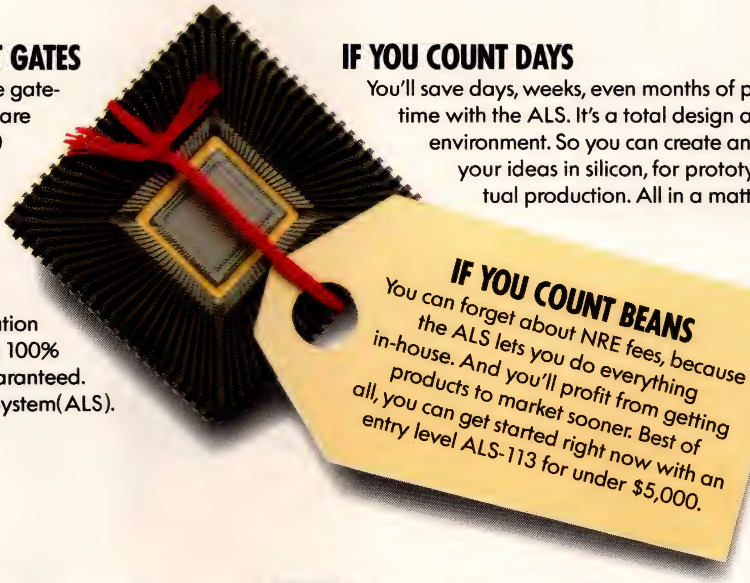

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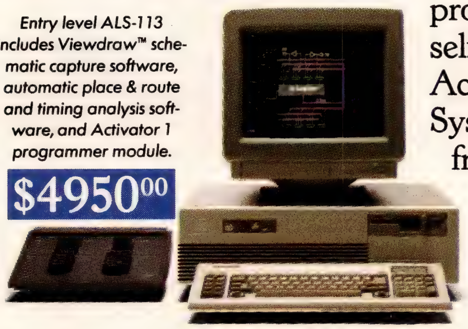

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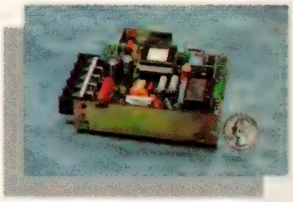

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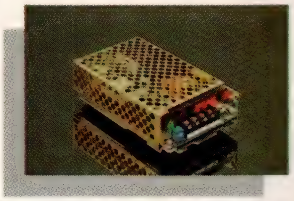

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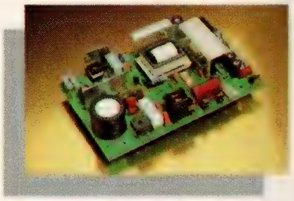

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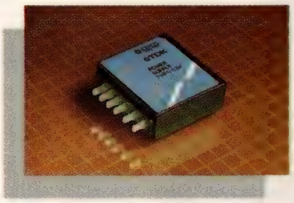

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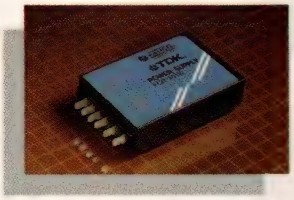

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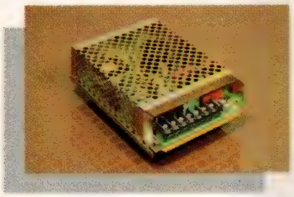

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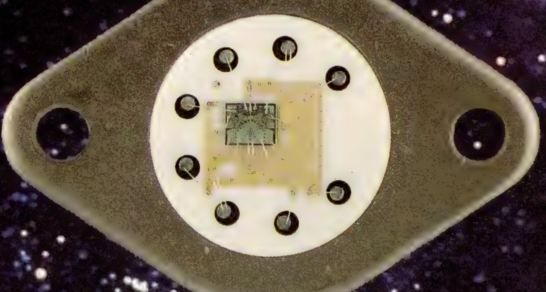

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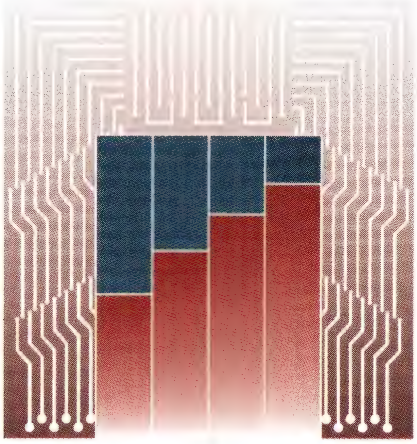

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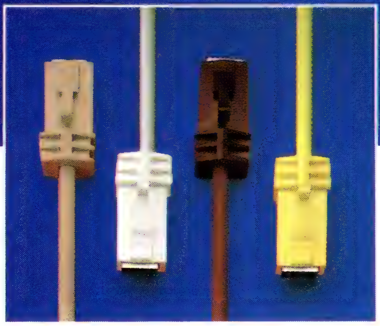

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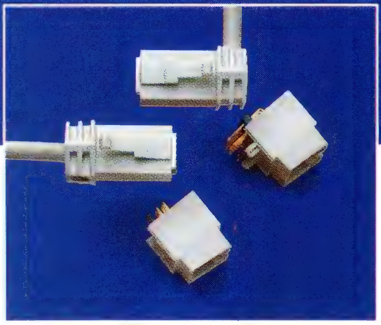

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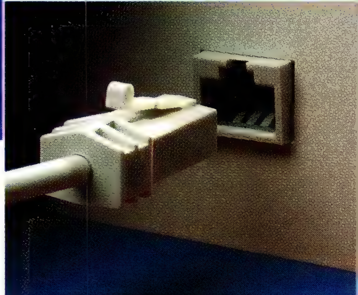

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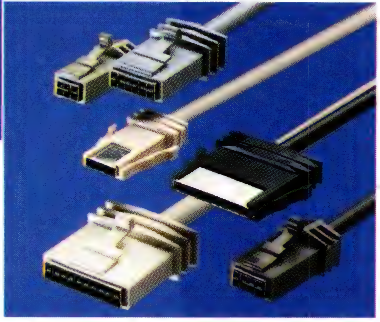

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OVERVIEW

How U.S. electronics CEOs will address the new competitive priorities

The significant survey results and the perspectives of industry leaders on the opportunities for success in the decade ahead

BY BRUCE C.P. RAYNER

The CEO's job is to think strategically: know the market, handle uncertainty and keep ahead of the pack. Shareholders demand it, customers expect it and suppliers depend on it. Successful strategies lead to faster sales growth and increased profitability. That's what the person in the corner office does.

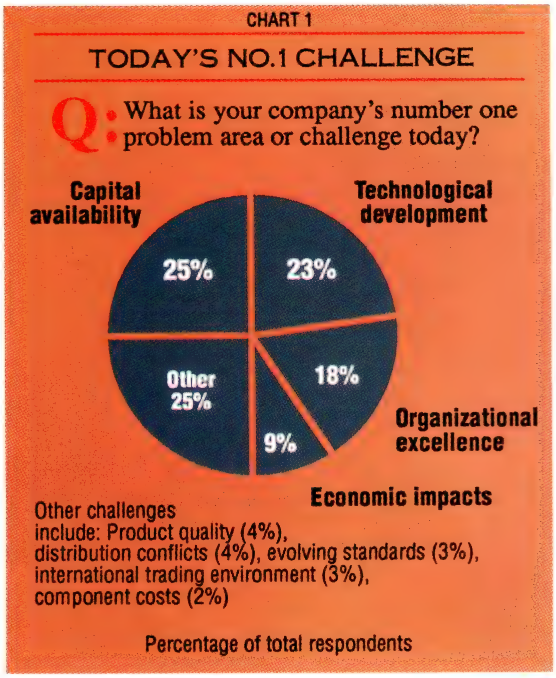
To see how chief executives are facing the challenges of the '90s, ELECTRONIC BUSINESS and Ernst & Young, one of the "Big Six" accounting and management consulting firms, polled over 750 of the U.S. electronics industry's CEOs and conducted many in-depth interviews.

Although no two companies are alike, there are several common, critical concerns among top executives. Throughout the survey and in many of the interviews, capital constraints struck the most resounding chord. The availability of capital is the most demanding issue facing CEOs today, according to the survey's respondents (Chart 1).

CHART 1

TODAY'S NO.1 CHALLENGE

Q: What is your company's number one problem area or challenge today?



Other challenges include: Product quality (4%), distribution conflicts (4%), evolving standards (3%), international trading environment (3%), component costs (2%)

Percentage of total respondents

Capital constraints are closely followed by technological development as the second most important concern facing CEOs. Even though individual CEOs are often optimistic about the futures of their companies, a sense of pessimism pervades the industry. Sixty-nine percent of all survey respondents believe that the United States is losing its technological edge. While the United States will continue to be strong in software and computer-aided design and manufacturing (CAD/CAM), the country will slip, relative to its major trading partners, in all areas. The hardest-hit segments will be microprocessors and computers (Chart 2).

The lack of ready capital and its high cost are blamed for everything from the declining number of start-ups to America's losses in technological superiority. For semiconductor companies, the issue is the sheer volume of capital needed for developing new technologies and manufacturing facilities. For start-ups, the key question is how to attract the attention of jaded venture capitalists.

For all companies, equity will continue to be the primary source of funding. Private equity is expected to account for over 20% of the total funding needs in five years, down from 43% today, while public equity will triple, to 30%. Debt and private equity will both decline as a percent of the total funding needed. Close to half of all CEOs expect to go to the public markets within the next five years, either for an initial public offering or for a subsequent round of financing (Chart 3).

Wherever capital comes from, the majority of chief executives expect to spend increasing amounts to build new facilities. While 13% expect to build in 1990, 53% expect to build between 1991 and 1995. The vast majority of facilities will go up in the United States, with Europe coming in a distant second and the Pacific Rim an even more distant third.

Research and development will

OVERVIEW

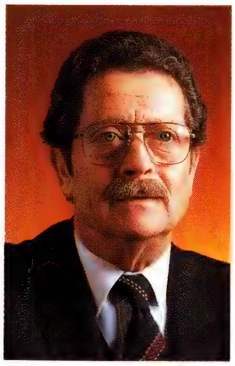
also place increasing demands on capital funds. Total R&D spending as a percent of sales will grow from an average of 9.5% of sales today to 9.8% in five years, according to the survey. The biggest growth will come from large companies in the communications, semiconductor and semiconductor equipment markets. For instance, the semiconductor market segment expects to increase R&D spending from 9.0% of sales today to 9.9% by 1995.

However, sources indicate that the rate of growth in R&D spending in the United States has been slowing in recent years and might continue that trend. Indeed, surveyed computer makers, industrial electronics companies and software vendors all plan to spend a lower percentage of sales on R&D over the next five years. Part of the problem is that competitive pressures are squeezing profits and putting the pinch on retained earnings. "Japanese competition [has] driven prices so low we can't afford development costs," laments one executive.

Executives are disturbed by the high relative cost of capital between the United States and Japan. Many CEOs complain that the cost of capital in Japan is less than half that in the United States. Adding to the capital burden in the United States is double taxation of corporate profits and dividends and the rescinding of the investment tax credit in 1986, say several executives.

Wall Street's short-term focus on quarterly performance has CEOs frustrated, too. Some 76% of all respondents believe that their industry's long-term prospects are constrained by the need to show quarterly improvements. Even venture capitalists are seen as bad guys because of their micromanagement and focus on very high return on investment. "Venture capital will be the death of high technology," comments one irate CEO.

But many CEOs are more pragmatic about the whole short-term/long-term debate and accept the constraints as part of the price of doing business. However, some CEOs think there is inadequate long-term planning in the industry and argue forcefully for a national technology policy. These executives point to national security as one reason to maintain a viable electronics industry.



Thomas Sege, chairman and chief executive, Varian Associaties

"We are one of the few major countries that not only doesn't have an industrial policy, but thinks that those words are dirty words," comments Thomas Sege, vice chairman of Varian Associates Inc. in Palo Alto, Calif. "There is a European industrial policy developing. Japan has had it for a long time, Korea has had it, we don't," he complains.

> "WE ARE ONE OF THE FEW MAJOR COUNTRIES THAT NOT ONLY DOESN'T HAVE AN INDUSTRIAL POLICY, BUT THINKS THAT THOSE WORDS ARE DIRTY WORDS"
>
> *Varian's Thomas Sege*

Working smarter

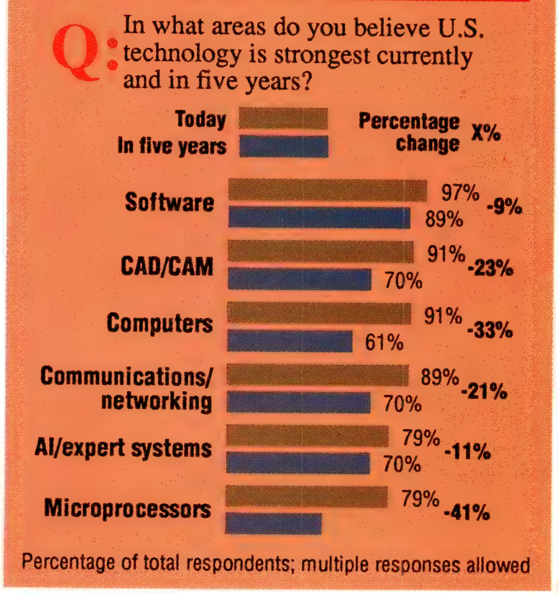
Capital contraints and competitive pressures are forcing CEOs to focus more strongly on their company's customers. Seventy-one percent of all CEOs surveyed think customer service will be a "very important" challenge in the next five years (Chart 4). Similarly, competitive advantage is determined by many criteria, but customer service is the only determinant that CEOs expect to become significantly more important in the future (Chart 5).

To deal with the challenges of the decade ahead, CEOs agree their companies must learn to work smarter. Reliance on government aid or protection is not popular. There is acceptance that the motivation to face the issues starts with the chief executive.

At the heart of a smarter company is the need to focus on the customer and develop a corporate culture of organizational excellence. Eighteen percent of the surveyed CEOs claim organizational excellence is the most critical issue they face today. That means higher quality in

CHART 2

SLIPPING TECHNOLOGY LEAD



Percentage of total respondents; multiple responses allowed

OVERVIEW

> “THE ‘90S WILL BE A TIME WHEN THERE CONTINUES TO BE TREMENDOUS CHANGE TOWARD STANDARDS, WHICH PUTS A BURDEN ON COMPANIES THAT CONTINUE TO SEARCH FOR AN ADVANTAGE”
>
> *Tandem’s James Treybig*

every facet of the company’s business, from technology to manufacturing to personnel.

Organizational excellence and customer service are tightly coupled. “The only way to find out whether you are excellent or not is by asking the customer,” according to Winston Hindle, senior vice president of operations at Digital Equipment Corp. “The only set of standards that make any sense to judge yourself on are those set by the customer.”

“Just having a unit that doesn’t break as often as the next guy’s isn’t enough,” insists Rod Canion, chief executive of Compaq Computer Corp. What’s needed is the right product — one that meets the needs of the customer and satisfies expectations. But while the United States has been doing a better job serving the customer in recent years, it still has a long way to go, admits Canion.

Meeting customer needs means keeping pace with advances in technology and applying technology quickly to new product development. Larger companies are most concerned with technological obsolescence, while small and midsized companies worry more about protecting their proprietary technology. The solution to both problems lies in more technology exchanges in the 1990s, according to survey results.

James Treybig, chief executive and president, Tandem Computers

Although technology development is a critical issue for the 1990s, many CEOs feel that having leading-edge technology is no longer enough to maintain a competitive advantage. Technology is only an invitation to participate, says Robert Schultz, chief executive of GM Hughes Electronics Corp. and executive vice president of General Motors Corp. “You have to have technology, but that’s not going to be enough to win. You have to have the cost [structure] and the quality and the reputation to be a player in the marketplace,” he says.

Closer ties

The “Not Invented Here” arrogance so prevalent in the 1970s and early 1980s is giving way to cooperative technology development among competitors and between suppliers and customers. Microcomputer manufacturers, for example, rely on microprocessor makers for a large part of the technology that goes into their systems.

At the same time, evolving standards are helping to establish closer relationships. “The ’90s will be a time when there continues to be tremendous change toward standards, which puts a burden on companies that continue to search for advantage,” says James Treybig, chief executive of Tandem Computers Inc.

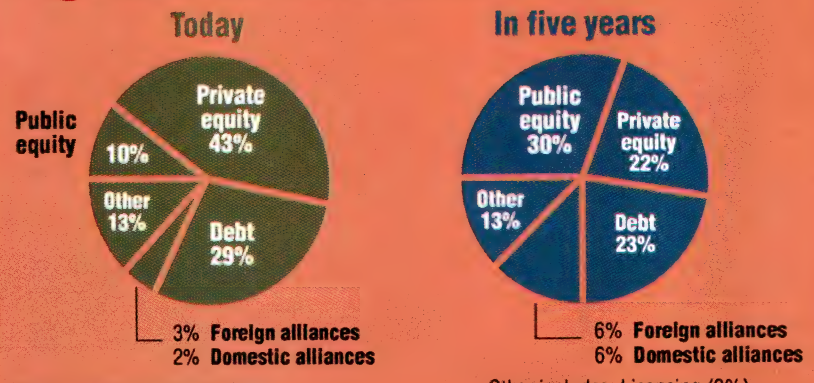
One CEO is improving customer relations by buying his customers’ stock and giving it to his own employees as a bonus. The stock purchases improve morale and have an effect on the quality of the products, says John Hanley, president of Chantal Systems Corp., a San Diego-based software developer.

But some U.S. electronics companies have a long way to go before suppliers and customers are truly partners. In electronics distribution, partnerships with customers are still rare. “You can count on both hands and both feet the number of true

CHART 3

WHERE CAPITAL COMES FROM

Q: Estimate, as a percentage of your total financing, the financial vehicles you are using and expect to use in five years.



Other includes: Licensing (2%),
Government grants (1%)

Other includes: Licensing (3%),
R&D partnerships (1%),
Government grants (1%)

Percentage of total funds

partnerships between distributors and customers today," says Stephen Kaufman, CEO of Arrow Electronics Inc., Melville, N.Y.

While customer service is a significant issue for all CEOs, it tends to be rated more highly by companies in the $25 million to $300 million annual revenue range. These are established companies, often on the fast growth track, that are heavily exposed to foreign competition. In terms of markets, communications companies, computer vendors and software firms are most concerned with customer service. In short, the higher the level of competition, the more the customer matters.

To raise the level of service, companies must be flexible enough to react quickly to a changing environment. Many CEOs favor a flat, decentralized management structure, in which problems are exposed immediately rather than being buried in bureaucracy. "Zero response time" is the name Steve Hui, chief executive of Everex Systems Inc., Fremont, Calif., gives to his company's corporate culture. "We rely on the possibility of people rather than the rigidity of our procedures," he says. Customer needs percolate up from sales and marketing, new ideas come from engineering and both flow to production and management.

People problems

For most companies, people are the key to competitive advantage. Indeed, a company is defined by the caliber of its employees. But many chief executives say finding and keeping good people will become more of a problem in the coming decade. It is rated as the second most important issue that CEOs expect to face during the next five years.

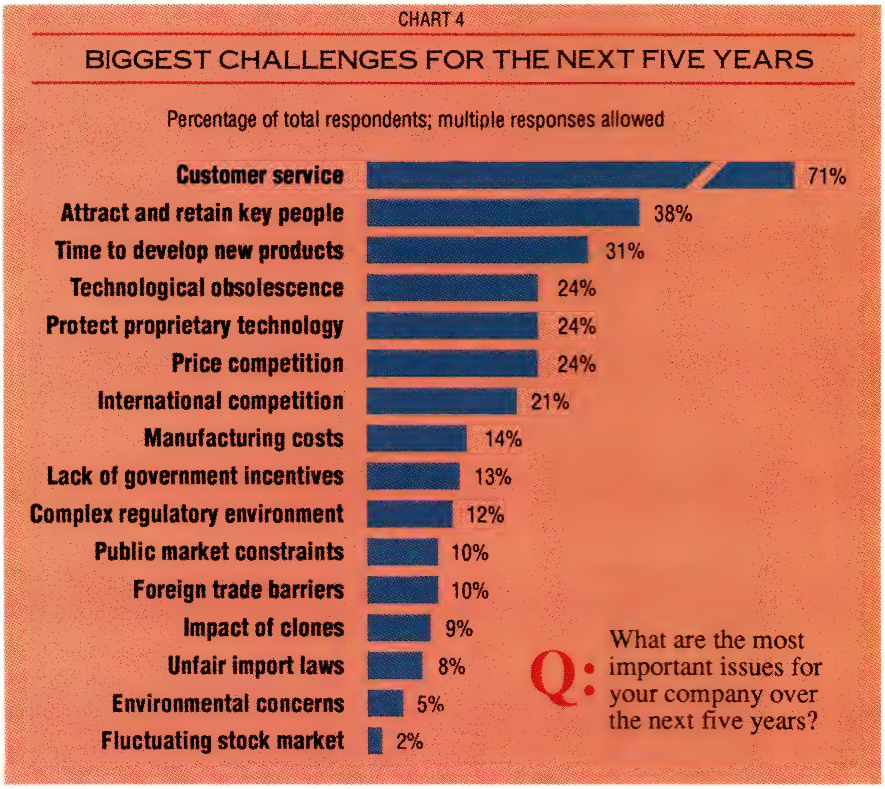
Hiring good people is often tied to other key concerns. Says one survey respondent: "Without adequate capital, we cannot afford the number and quality of employees needed to achieve our goals [of growth]."

The problem is twofold. First, how to find qualified candidates. The underlying problem here is in the quality of the education system. Many companies are forced to provide basic training in math and English in order for workers just to understand their jobs.

With the gradual deterioration of the public education system in many

CHART 4

BIGGEST CHALLENGES FOR THE NEXT FIVE YEARS



Q: What are the most important issues for your company over the next five years?

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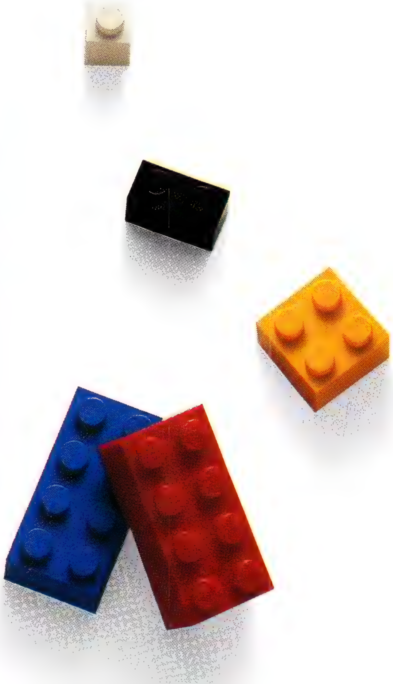

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OVERVIEW

> "WE SEE 1992 AS REALLY A MAJOR DRIVING FORCE IN THE EXPLOSIVE GROWTH OF THE EUROPEAN COMPUTER INDUSTRY TODAY"
>
> *Compaq's Rod Canion*

areas of the United States, the attractiveness of studying math and science has also waned. As a result, there has been a decline in the number of engineering graduates. Many science and engineering graduates are foreigners who must return home when they finish their studies. Competition for the best is getting fierce and will get worse in the future, say worried chief executives. The situation "stinks," says Craig Barrett, execetive vice president at Intel Corp.

Rod Canion, chief executive, Compaq Computer

The second problem is keeping employees once they have been hired. Mobility of skilled labor and the lure of higher pay elsewhere have created problems of continuity for many technology companies. CEOs recognize the need to create a continually challenging and supportive environment for their employees.

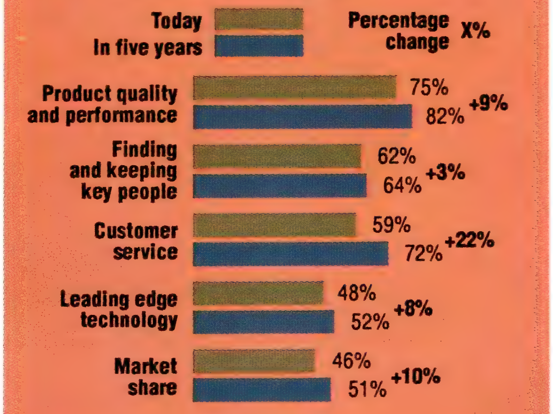
That involves empowering the employee, says Varian's Sege. Pride in accomplishments has to be instilled. But instilling pride in one's work is a long-term cultural change, and time is a critical issue. "Whether we can really create the motivation to have a more effective work force — that's the real question," says Sege.

The government certainly has a role to play in improving education. But it also has a role to play in preserving the country's electronics industry. At the top of the list of concerns, surveyed CEOs think the government should provide better financial incentives for the industry. Popular suggestions include low-cost loans, a capital gains differential and more research and development incentives.

CHART 5

U.S. COMPETITIVE ADVANTAGES

Q: Rate the importance of the following in establishing your company's competitive advantage.



Percentage of total respondents; multiple responses allowed

One factor in the high cost of capital is the government's budget deficit. A reduced budget deficit would help lower interest rates and bring capital costs down. Some 20% of CEOs see the budget deficit as the most serious macroeconomic problem for their own long-term health.

Even though government has a role to play, most CEOs think the Feds should stay at arm's length from the electronics industry. When dealing with trading partners, CEOs do not want protectionist walls built around their markets. Instead, the government should turn its attention to negotiating trade agreements at the highest, broadest levels, industry executives say. Japan is at the top of the list for such trade agreements, closely followed by Western Europe and the Pacific Rim countries.

While overseas trade agreements are favored, CEOs differ over the government's role in consortia. Aside from funding, the government's primary role in consortia should be to relax the anti-trust regulations, say several executives. At stake, say such consortia supporters, is the future of the electronics industry: in particular, the semiconductor and semiconductor equipment industries.

On the other hand, many CEOs question whether the cultural basis for consortia is lacking in the United States. "By and large, I'm not sure that competitors know how to deal with each other yet," says Edward Esber, chief executive of Ashton-Tate, Torrance, Calif., "whereas in Japan, consortia are ingrained and they work well."

Foreign markets

While competition with foreign companies is on the minds of most CEOs, it is not a high priority. International competition is ranked only seventh as a key business issue for the future, while foreign trade barriers and unfair import laws rank even lower.

Foreign competition tends to be a big company issue. For companies generating between $100 million and $300 million in annual revenue, for instance, international competition, foreign trade barriers and unfair import laws are ranked sixth, seventh and eighth, respectively.

As expected, international competition is important for companies that face domestic competition from overseas companies. For instance, industrial electronics companies rate international competition fourth in terms of key issues, while semiconductor and semiconductor equipment makers rank it fifth. These companies also tend to be the most vocal about wanting tougher trade restrictions.

At the other end of the spectrum are software companies, which see little or no competitive pressures from overseas, particularly from the Far East. "I think it is difficult for the Japanese marketplace to develop software," says Charles Wang, chief executive of Computer Associates International, Garden City, N.Y., the largest software company in the industry. "I think their thinking is different. It is more structured, too structured almost."

However, Jon Shirley, former chief operating officer at Microsoft Corp., Redmond, Wash., doesn't think Japan should be ignored. "To the extent that there will be offshore competition [in software], I would most likely expect that it would come from Japan," says Shirley.

U.S. expansion overseas

As for expansion by U.S. companies into other geographic markets, Europe is considered by U.S. companies to be the most important foreign market to enter. Over the next five years, 43% of all CEOs surveyed expect to target Europe, up from 27% today.

The primary interest in Europe is fueled by the European Community's plans to dismantle intra-European trade barriers by the end of 1992. Says Compaq's Canion: "We see 1992 as really a major driving force in the explosive growth of the European computer industry *today*." As European businesses prepare for the changes coming during the next two years, they have to invest now in productivity-enhancing computer resources, he says.

Fifty-one percent of all CEOs think that the changes taking place in Europe will have a positive impact on their companies. Software companies are the most optimistic, while larger companies in all markets tend to be more pessimistic.

The dramatic changes occurring in Eastern Europe were unfolding as the survey was being conducted, so the impact of those events is difficult to assess. However, many CEOs interviewed at the end of 1989 believe that the main benefits of a freer Eastern Europe will go first to Western European companies, particularly West Germany. U.S. involvement won't be significant until the end of the decade, they claim.

As markets open up in Europe and elsewhere around the world in the 1990s, distribution is going to become a more pressing issue. But surprisingly, distribution channel conflicts are not considered serious problems by the majority of companies surveyed. However, many chief executives interviewed raised the issue of their company's distribution strategy as a key issue for the next few years.

Overall, distribution channel conflicts tied for fifth as the most critical issue of the day by all CEOs surveyed. In general, large communications and computer and peripherals companies rank distribution conflicts as relatively more serious compared to other company categories. The reason is that with a growing reliance on indirect distribution channels in these markets, particularly overseas, relinquishing control can create conflict.

"In the '90s, we're going to have to find newer and better ways to protect gross margins other than just straight price competition and I think the key to it is distribution channels," according to Frank Buckley, vice president and general manager of Toshiba America Information Systems Inc.'s disk products division. That involves maximizing the economic life of products by using indirect distribution channels more effectively.

There are ways to supplement traditional distribution channels. Many companies are shifting toward telemarketing their products. Telemarketing accounts for a higher percent of sales than in the past and will continue to grow in importance, say many CEOs interviewed. This is being driven partly by the increasing cost of maintaining a field sales force and partly by the "consumerization" of electronics. □

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CRITICAL ISSUES

Globalization is the driving force

Where the threats and opportunities lie in the increasingly competitive international markets and how CEOs are responding

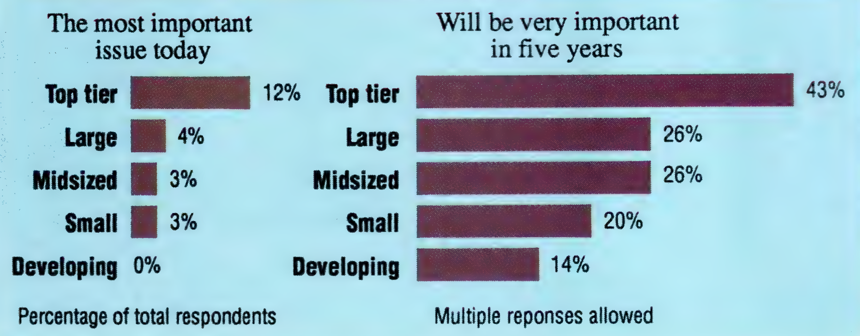
The globalization of electronics is reality. International trade drives the worldwide electronics industry, affecting virtually every key business decision made today. For the most part, chief executives of U.S. electronics companies are optimistic about the global business environment. They see strong growth prospects for their products overseas, as much of Western Europe consolidates and the Far East begins to mature.

To survive in the global market, the best defense is a strong offense. Increasingly, foreign sales are greater than domestic sales for many of the industry's leading companies, including IBM, Hewlett-Packard Co. and NCR Corp. According to the ELECTRONIC BUSINESS 200, a list of the top U.S. electronics companies, foreign sales have been growing as a percent of total sales throughout the late 1980s. In 1988, 31.5% of sales by the top 200 were overseas, up from 25% in 1987.

"One of the significant issues that American companies are having to face is the ability to manage their business when more than 50% of their market is outside the country," argues T. Kevin Dunnigan, chief executive of Thomas & Betts Corp., a connector manufacturer based in Bridgewater N.J. That means relinquishing control to regional headquarters and creating a more horizontally managed company.

CHART 1

FOREIGN COMPETITION: A GROWING CONCERN



A big-company issue

Foreign competition is seen as a critical issue primarily by big companies. Overall, international competition ranked seventh on a list of eight major concerns of executives surveyed. But for companies with annual sales of $300 million and above, international competition was ranked third, with 12% of the CEOs claiming it to be the most challenging issue they face (Chart 1).

Although foreign competition is intense now, many CEOs expect it to get worse in the future. "It used to be a three-and-a-half segment market — the U.S., Europe, Japan and the four Tigers [Hong Kong, South Korea, Singapore and Taiwan]. Now it's clearly a single market, and that has to be in the forefront of all CEOs' strategic thinking about how to survive in the 1990s," comments Stephen Kaufman, CEO of Arrow Electronics Inc., Melville, N.Y., an electronics distributor.

Indeed, foreign competition is driving many of the CEOs' strategic concerns. For instance, the need for better customer service, improved organizational excellence and higher quality often stem from growing international competition.

CEOs of American companies tell stories of how they cannot get domestic suppliers to provide parts that are of sufficiently high quality. Robert Shillman, CEO of Cognex Corp.,

CRITICAL ISSUES

Needham, Mass., says he was willing to pay a 20% premium to an American vendor for a telephone system, but ended up buying from a Japanese company because there was no U.S. vendor that could match the quality and service. "I'm very disappointed about that," says Shillman.

The same stories abound in printed circuit boards, components and semiconductor equipment. To compete, U.S. companies have no choice but to raise the standard of quality. Keithley Instruments Inc., a Cleveland-based manufacturer of semiconductor test equipment, had a quality culture imposed by its Japanese partner that has led to improved quality for all customers worldwide, says Thomas Brick, Keithley's chief executive. "When we send our instruments over to Japan, our trading partner will completely analyze them before he'll even think about promoting them," says Brick.

Thomas Bruggere, chairman and chief executive, Mentor Graphics

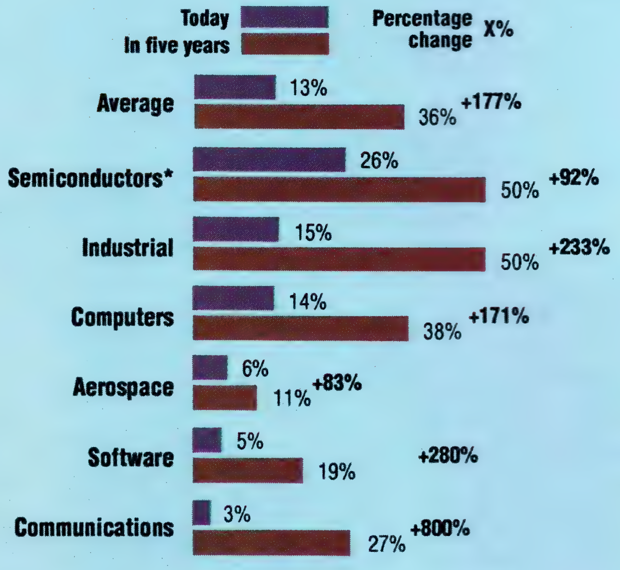
Improving quality for foreign customers is only part of the problem. The U.S. government's confused attitude about promoting exports is also a hindrance to global competitiveness, say CEOs. The Department of Commerce issues export licenses, but a number of other agencies have veto power. CEOs argue there is a real need for a more efficient mechanism in Washington to coordinate exports. "Our country is the most restrictive as far as [export] regulations are concerned," complains Safi Qureshey, chief executive of AST Research Inc., Irvine, Calif.

"You must have a government that provides a stable and reasonable climate within which to do business," says Keithley's Brick. His company recently contracted to sell a $1000 piece of hardware to a Hungarian company, but, because of the verification required by the U.S. government, Keithley decided it just wasn't

CHART 2

MORE COMPETITION FROM OVERSEAS

My primary competitors are foreign



* Includes components and semiconductor equipment

Percentage of total respondents

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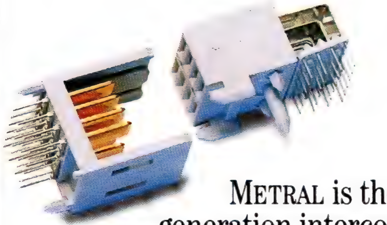

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And that's just the beginning.

METRAL cuts costs by shortening the design cycle.

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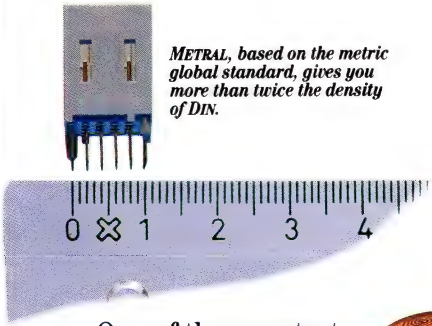
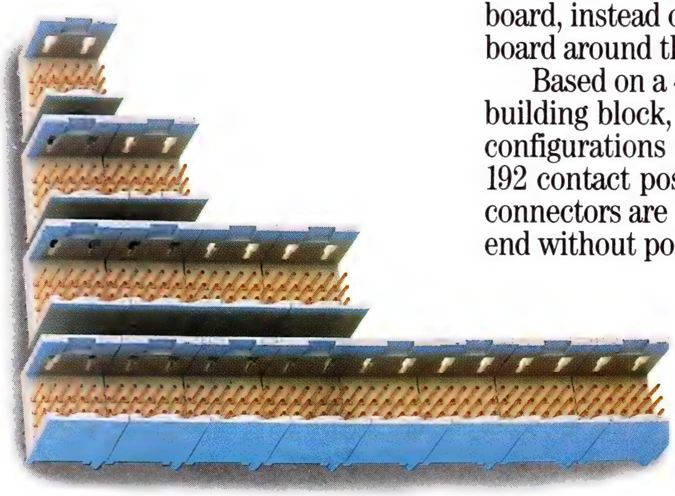


METRAL, based on the metric global standard, gives you more than twice the density of DIN.

One of the smartest features of METRAL is that it's designed with today's—and tomorrow's—high density requirements in mind.

METRAL connectors are based on a 2.0 millimeter grid (an excellent balance of density, cost and durability), and provide up to 432 signal positions on a double Eurocard. Which means, in the same amount of space, METRAL packs more than twice the position density of DIN 41612.



METRAL offers stackable end-to-end configurations o 24, 48, 96 and 192 contacts- without position loss.

Affordable, cost-effective density like that makes METRAL indispensable if you want the most value possible from available real estate.

To put it another way, the more functions you pack on a board, the more you need METRAL.

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Because of its uniform module design METRAL is remarkably adaptable. This allows you to design the connectors around th board, instead of designing the board around the connectors.

Based on a 4x6 position building block, METRAL offers configurations of 24, 48, 96 and 192 contact positions. And the connectors are stackable end-to-end without position loss. You ca use the same footprint for signal and power modules. If you don't need a module, the space saved on the board can be used for som thing else.

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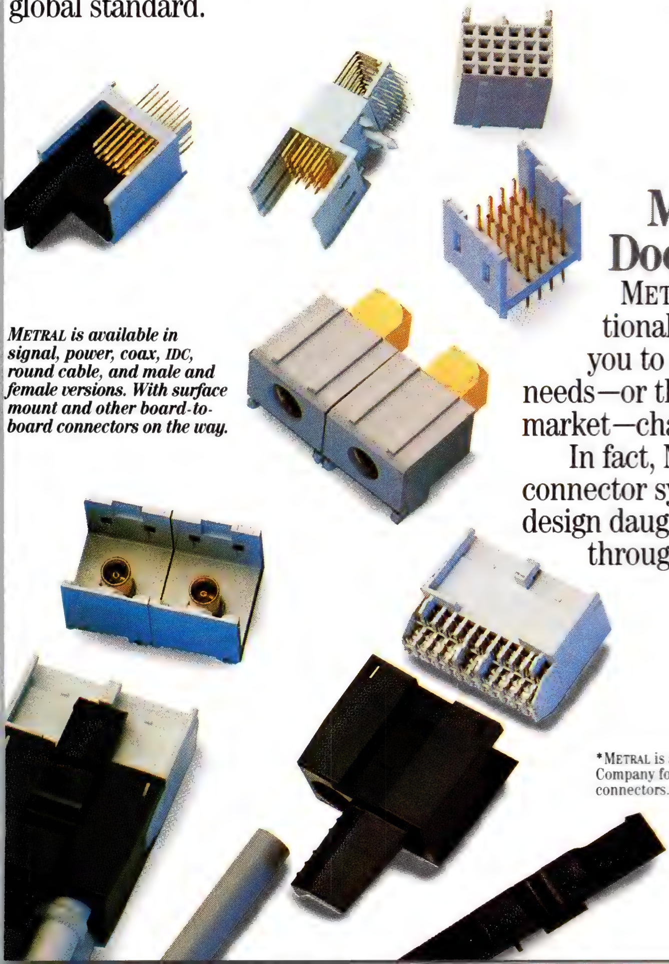
Thanks to its "building block" approach, METRAL affords designers limitless creativity by standardizing the configuration of the connectors. That means you can standardize across your entire product line—whether data processing, telecommunications or instrumentation.

What's more, since METRAL connectors can be qualified as a system, you can reduce approval time.

And with metric standardization on the way, designing with METRAL makes even more sense. Because METRAL already meets the metric global standard.



METRAL is available in signal, power, coax, IDC, round cable, and male and female versions. With surface mount and other board-to-board connectors on the way.

METRAL Does It All.

METRAL is multifunctional enough to allow you to expand as your needs—or the needs of the market—change.

In fact, METRAL is the first connector system that lets you design daughter cards for through-hole or surface mount without redesigning the backpanel system.

METRAL is available in signal, power, coax, IDC, round cable and male and female solder-to-board versions. And shielded cable connectors, surface mount, fiber optic, press-fit and high speed board-to-board connectors are on the way.

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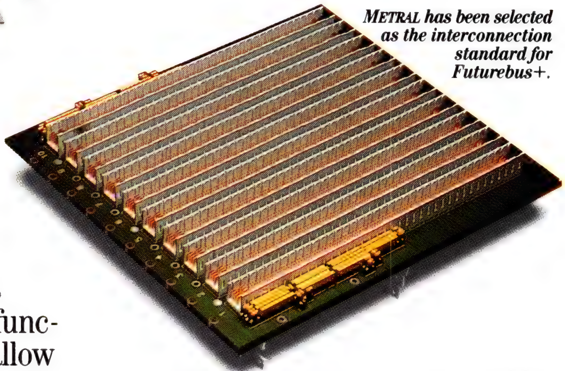

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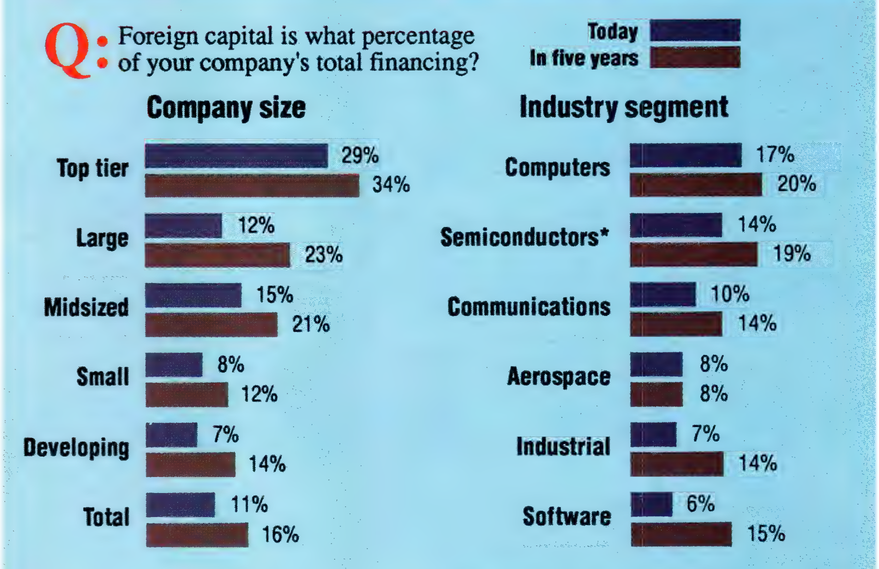
worth the effort. The reason for all the red tape was that the package included a low-tech microprocessor, Brick says. Subsequently, a foreign competitor got the contract.

For Progress Software Inc., a $25 million Bedford, Mass., software developer, getting an export license "was a nightmare," says Chad Carpenter, the company's president. "The U.S. government was as confused as anybody."

CHART 3

OVERSEAS CAPITAL TO PLAY A BIGGER ROLE



* Includes components and semiconductor equipment

Where will competition come from?

Western Europe will provide possibly the greatest immediate competitive threat as 1993 draws near, say CEOs. While 14% of companies expect the breakdown of intra-European trade barriers to have a negative impact on their companies' sales in Europe, 30% believe it will be negative for their industry. Chief executives fear the rise of European nationalism.

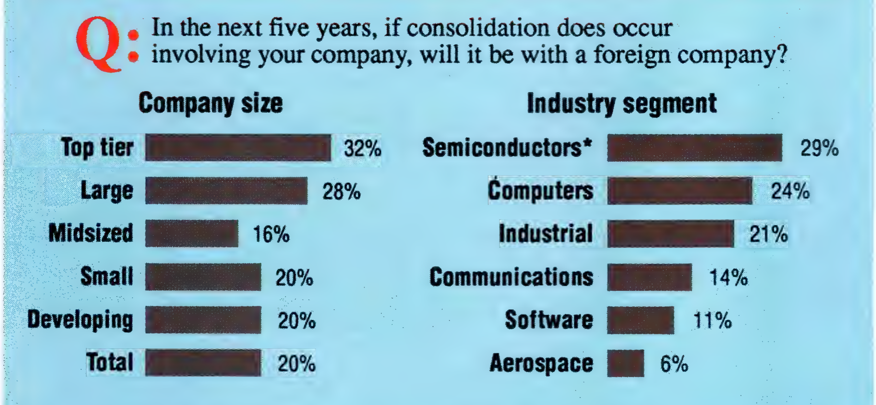
Craig Barrett, senior vice president at Intel Corp., Santa Clara, Calif., sees Europe 1992 as a "veiled threat." His concern is that as trade barriers fall between EC countries, "there may be tacit agreements among purchasing agents to buy European." It will make little difference what the government rules and regulations are if European buyers decide to patronize European companies. For instance, only European semiconductor makers are currently allowed to participate in the Jessi consortium — Europe's answer to Sematech — and there is discussion of increasing the European content of imported goods.

Thomas Sege, chairman and chief executive of Varian Associates Inc., Palo Alto, Calif., agrees: "I don't know about 'Fortress Europe,' but there may be a Europe with a picket fence around it — a selective tariff barrier."

One of the big question marks in the 1990s will be the development of Eastern Europe as a potential competitor. Most CEOs view the revolutionary changes taking place there as opportunities rather than as threats, but some see the long-term possibilities of competition.

CHART 4

M&A WITH FOREIGN COMPANIES TO INCREASE



Percentage of total respondents

* Includes components and semiconductor equipment

While the Communist countries are expected to shift gradually toward market economies, they will not copy the U.S. free-enterprise model, speculates Griffith Resor, chief executive of MRS Technology Inc., a flat panel display company in Chelmsford, Mass. Instead, they may pick the Japanese model of strong government involvement, and in that way could prove formidable competitors, he says.

Whether Japanese or European, a growing number of U.S. electronics companies expect that in five years their primary competitors will be foreign. The worst-hit will be the industrial electronics and component makers who both expect 50% of their competition to come from overseas, up from today's 15% and 26%, respectively (Chart 2).

The biggest change, however, will occur in the voice and data communications market. CEOs expect an eightfold increase in foreign competition, from 3% today to 27% in five years. The reason is the general openness of the U.S. telecommunications market and the move toward international standards. Both will lead to an increasing number of overseas com-

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panies selling into the United States in the future.

Somewhat surprisingly, the second-fastest-growing area in foreign competition will be software. Today, 5% of all software companies face a primary competitor from overseas, but in five years that will rise to 19%, say surveyed software vendors. This may be due, in part, to the growing Japanese focus on software. Other countries with software expertise, including several European countries, Singapore and India, are also expected to come on strong in the 1990s.

Foreign acquisitions

Acquisitions by and alliances with foreign companies will continue to play a key role in the U.S. electronics industry. Foreign capital currently accounts for 11% of total capital of the companies surveyed, but over the next five years that figure will increase by 45%, to 16%. The highest growth will come from developing companies, but large companies expect to account for the highest percentage of foreign capital (Chart 3).

Foreign acquisition will involve companies of all sizes. According to the survey, 88% of all companies with sales of $300 million and above expect to acquire other companies within the next five years, while 18% of the same group expect to be acquired. Thirty-two percent of these top tier companies expect to consolidate with a foreign company (Chart 4).

Even though competition is increasing, the cry for protectionism is largely absent. Most CEOs interviewed expressed the belief that the government's role should be to create an environment in which U.S. companies can compete more effectively against foreign companies. This includes tax incentives for capital investment, research and development spending and relaxing the antitrust laws to allow for consortia.

The government's role "should be focused on the opportunities where we can make a difference in the future, as opposed to protect a historically bad situation," says James Morgan, chief executive of Applied Materials Inc., a leading U.S. semiconductor equipment manufacturer in Santa Clara, Calif. That means government support for key technology sectors, including semiconductors and semiconductor manufacturing.

But there is also a need to protect indigenously created technology. In all, 24% of CEOs surveyed believe that this is a very important issue for the next five years. Similarly, 39% believe the government could do more to protect domestically developed technology.

"We have to hold on to U.S. technology and figure out better ways of taking that technology to the world," suggests Thomas Bruggere, chairman and chief executive of Mentor Graphics Corp., Beaverton, Ore. One proposal for keeping better U.S. control over indigenously created technology would be to create a disincentive system for technology transfer, he says.

According to the survey, most companies sell in Canada and Europe, while close to half sell in Japan and the Pacific Rim. Europe is expected to be the most important market in the next five years because of its size, followed by Japan, the Pacific Rim and Canada, in that order (Chart 5).

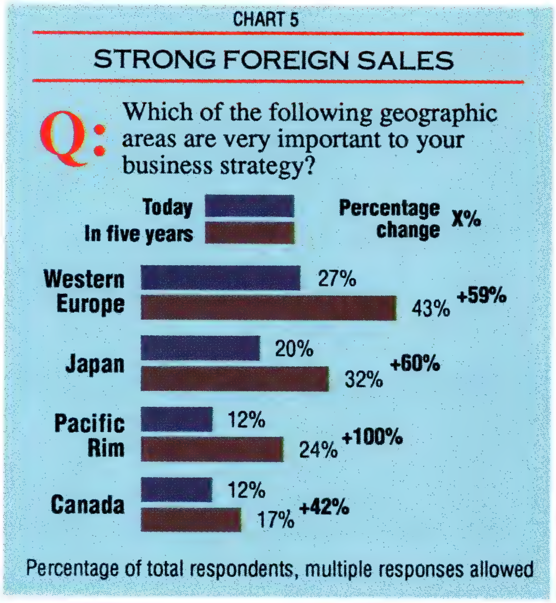


CHART 5

STRONG FOREIGN SALES

Japan continues to be the hardest market to penetrate. Thirty-one percent of all companies surveyed that have attempted to sell in Japan admit to having failed (Chart 6). The common complaint is the Japanese government's restrictions on imports, and "cultural" differences. But successful U.S. companies say it is a question of understanding the market and working with the system. "Whether you sell in Angola or Japan, you have to understand the rules of the game," notes one chief executive.

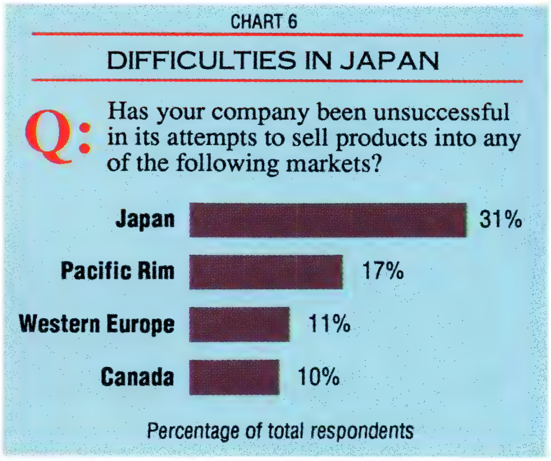


CHART 6

DIFFICULTIES IN JAPAN

If Europe is the most important market, and Japan the toughest, then the most dynamic will be the Pacific Rim. Twelve percent of all CEOs say the region is very important to their strategy now, but in five years that figure will double, to 24%. While part of the strategic importance of the Pacific Rim is bolstering sales to the increasingly affluent economies of the region, the other advantage is cheap manufacturing.

A number of companies, mainly the larger ones, either have their own facility overseas or use third-party manufacturers. Many expect to build new facilities overseas in the next five years. After the U.S., Europe is the most popular location, followed by the Pacific Rim. Fifty-one percent of top-tier companies will build new facilities in Europe. Location in Europe is planned mainly to gain proximity to the market, while building in the Pacific Rim is driven by low labor costs. ☐

The changing structure of capital formation

Capital is the dominant issue today. Where it comes from, how much it costs and how it will be used are shaping the industry of tomorrow

Capital tops the list of immediate concerns for the chief executives in the U.S. electronics industry, according to the results of the ELECTRONIC BUSINESS/Ernst & Young CEO survey. Twenty-five percent of the 750-plus chief executives surveyed named capital availability as their most pressing problem today. The issue came up repeatedly in all the interviews and round-table discussions that followed the survey.

Two issues concerning capital are particularly frustrating for CEOs. First, the relative cost of capital is high in the United States. The U.S. prime lending rate is around 10%, while Japan's hovers below 5%. The U.S. government is largely responsible for the high interest rates, say CEOs. A concerted effort is needed to reduce the budget deficit below the 1989 level of $152 billion, which will help relieve pressure on interest rates.

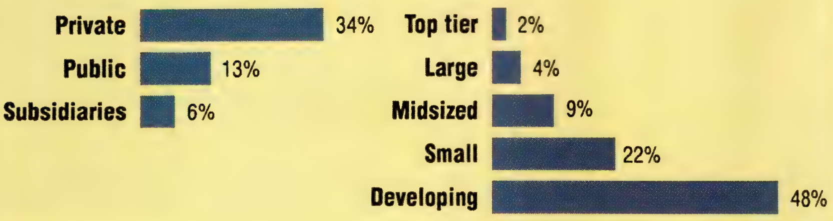
The second concern is the short-term stranglehold that Wall Street has on public companies and that private investors — venture capitalists, especially — tend to put on private companies. CEOs complain that they must compromise long-term strategic planning in order to show a profit for the next quarter. "Unless we can fix it, get more of a long-term orientation, it will portend serious problems for companies," warns Edward Esber, CEO of Ashton-Tate, Torrance, Calif.

Many executives share Esber's view. They believe that the short-term focus is creating an industrial structure in the United States that presages a continued deterioration in international competitiveness. These CEOs point to the continuing focus of high-technology companies solely on core businesses as a symptom of this short-term mentality. Companies often sell unprofitable divisions to satisfy short-term financial performance criteria, even though these divisions might hold the possibility of long-term viability.

CHART 1

SMALL PRIVATE COMPANIES' CAPITAL WOES

Percentage of total respondents saying capital availability is their number one problem area today



One suggestion for ways to help the short-term/long-term situation is to reinstate the capital gains tax differential for money invested over the long haul. "Without the incentive of long-term capital gains in the early '80s or late '70s, there wouldn't have been the pool of venture capital that started my company," argues Robert Shillman, chief executive of Cognex Corp., Needham, Mass.

The Tax Reform Act of 1986 made the top income tax rate equal to the capital gains tax rate —thus removing an important incentive to take entrepreneurial risks, many CEOs argue. A reinstatement of the differential is important, many executives say, but it should be legislated only for long-term investments, to minimize short-term speculation.

While most CEOs rail against the short-term mentality of narrow-minded investors, capital availability is most acute for start-ups. Forty-eight percent of all companies with

CRITICAL ISSUES

Gabriel Fusco, chairman and CEO of Sequoia Systems

sales under $5 million cite capital availability as their top problem. The concern drops off dramatically as the company size increases. But because developing companies account for 30% of all companies surveyed, and a substantial percentage of the industry at large, capital availability is viewed by many as a central issue for the industry's future health (Chart 1).

Despite their distrust of Wall Street, most CEOs expect to go to the public markets for capital in the near future. The greatest increase will be among developing companies, which expect 23% of their total funding to come from public markets by 1995, up sharply from 4% today (Chart 2). Over the next five years, 46% of all developing companies expect to go to the public markets for either an initial public offering or a secondary offering.

"The advantages of being public in the United States, unfortunately, do outweigh the disadvantages," insists Gabriel Fusco, chairman and chief executive of Sequoia Systems Inc., in Marlborough, Mass., a manufacturer of on-line transaction processing systems. For many start-ups, the initial public offering is a rite of passage and earns the company much-needed respect. Having a stock symbol next to your name makes the difference when trying to sell a million-dollar system, says Fusco.

But going public is not as easy as CEOs may expect. The cost of funds is still high and investor sentiment toward high technology is low, so the dream of an IPO might not materialize for many developing companies.

A slowdown in start-ups

If the IPO market is sluggish, the flow of seed money is downright glacial. The consequences for the electronics industry are serious. According to the survey, the number of companies formed between the early 1960s and 1984 showed a steady rise, but over the past five years the rate has dropped dramatically (Chart 3).

From a high in 1984 of 65 new companies, the number of start-ups among surveyed companies dropped to only 18 in 1988. While there may be some bias in the sample toward older, established companies, there is no mistaking the general downward trend. The decline is evident in all market segments, from aerospace and defense to software.

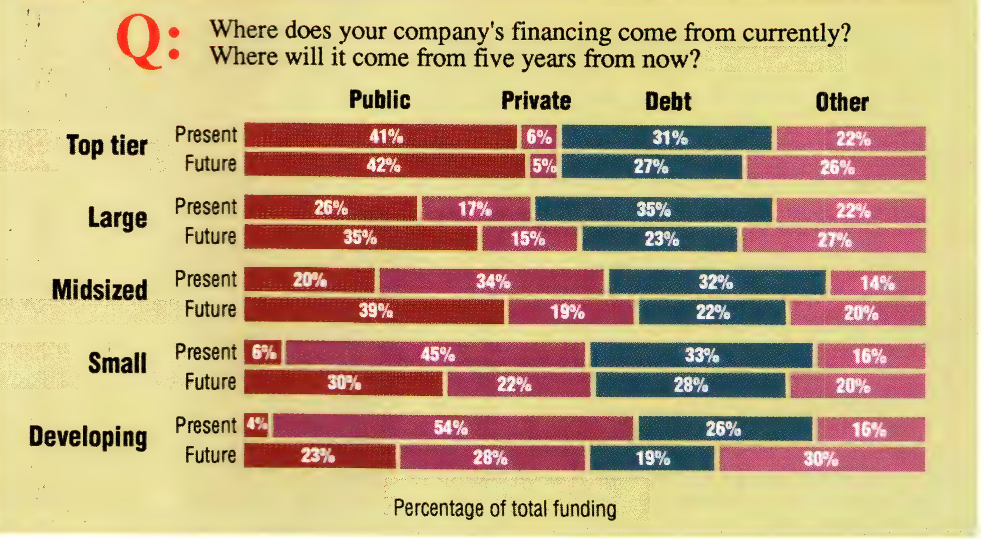
What's causing the slowdown? The root of the problem lies with capital funding. The recent trend of high interest rates, slower economic growth and slower growth in venture funding bodes ill for the industry's new blood. A dramatic slowdown in start-ups is predicted by the survey unless new sources of funds are found.

Contributing to the slowdown is the sluggish growth of research and development spending since the early 1980s. According to Data Resources Inc., an economic forecasting firm in Lexington, Mass., total industry R&D spending growth has dropped from a 10-year average of 12.7%, be-

> "THE ADVANTAGES OF BEING PUBLIC IN THE UNITED STATES, UNFORTUNATELY, DO OUTWEIGH THE DISADVANTAGES"
>
> *Sequoia System's Gabriel Fusco*

CHART 2

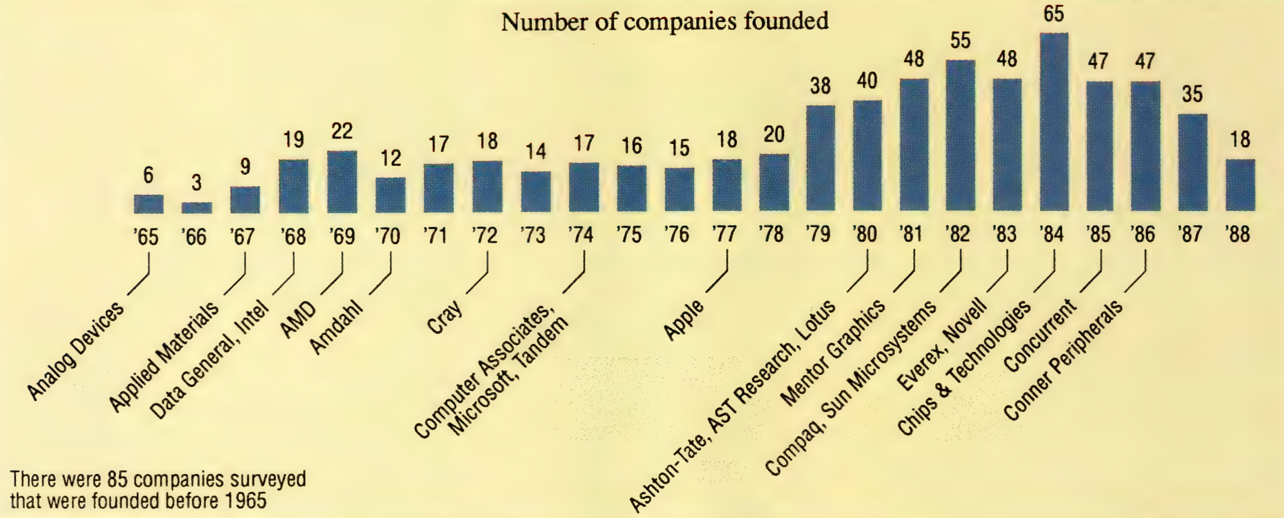
PRESENT AND FUTURE SOURCES OF FUNDING



CRITICAL ISSUES

CHART 3

DRAMATIC DROP IN NUMBER OF START-UPS



There were 85 companies surveyed that were founded before 1965

tween 1975 and 1985, to just 4.7% in 1988. According to those companies surveyed, R&D spending will grow from 9.5% of sales today to 9.8% in five years.

The National Science Foundation reported in January that total U.S. R&D spending adjusted for inflation actually declined by 0.9% between 1988 and 1989. Some analysts argue that as R&D spending slows, so will the development of new products and new companies.

New sources of funds

If conventional venture capitalists won't back new start-ups, entrepreneurs will be forced to go elsewhere. The most likely direction is to look for a strategic alliance with a larger company. Such a strategy serves both participants well: the start-up gets its money, and the large company gets advanced technology.

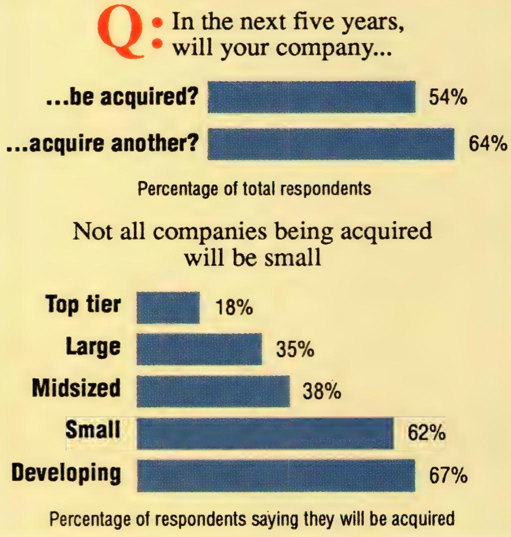
Most strategic alliances have been in the form of marketing agreements, but in the next five years electronics companies expect to see significant growth in technology alliances. Forty-five percent of the CEOs surveyed said their companies currently license technology; in five years, that number will grow to 54%.

Another option for the high-growth company in search of funds is to be acquired. A startling 54% of all the companies surveyed expect to be acquired within the next five years (Chart 4). While 67% of all developing companies expect to be bought out, some 18% of all companies with sales of $300 million and above also expect to be acquired. In cases where consolidation will take place, 20% of the companies surveyed expect that consolidation to involve a foreign company.

More and more often, CEOs are looking overseas for new sources of capital. According to the survey, foreign capital will see a rise in popularity over the next few years. From an average of 11% today, CEOs expect foreign funds to account for 16% of their total financing needs within the next five years.

CHART 4

ACQUISITIONS INTENSIFY



For computer and peripherals companies, 20% of all funding will come from overseas, up from 17% today. Software companies expect the most dramatic rise in foreign dependence. Today, software companies get only 6% of their funding from overseas, but by 1995 that figure is expected to rise to 15%.

The influx of foreign capital will bring with it a change in strategic focus, according to Peter Johnson, president of Eltech Electronics Inc., a contract manufacturer with facilities in Singapore and North Billerica, Mass. "As Japanese companies and other companies take larger positions in U.S. companies, there will be a different set of ground rules as to what is considered good performance."

Foreign ownership — especially Far Eastern ownership — means more of a focus on a company's long-term market positioning. For many U.S. CEOs, that would be a welcome change. ☐

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Shift in focus for strategic alliances

Partnering is on the upswing for technology, product development and manufacturing, but not all alliances are growing in popularity

The overwhelming majority of CEOs believe that strategic alliances will become more important for their corporate strategies over the next five years. Manufacturing and technology alliances will grow markedly but marketing agreements are likely to decline, say chief executives.

CEOs expect manufacturing alliances to grow by 33% and technology alliances to post a 20% growth during the next five years. Research and equity alliances will also see significant gains in the next five years. Marketing agreements, the long-standing favorite in joint ventures, will decline by 9%, say the chief executives surveyed (Chart 1).

The decline in marketing agreements and growth in other types of alliances point to a structural change in corporate relationships for the 1990s. Many companies are hoping to strengthen technology and product development ties, while weakening product distribution ties.

Companies with annual sales of $300 million or more will experience the sharpest decline in marketing alliances in the next five years. Software companies are most likely to reduce reliance on marketing agreements, while computer and peripherals makers say they expect to increase marketing agreements (Chart 1).

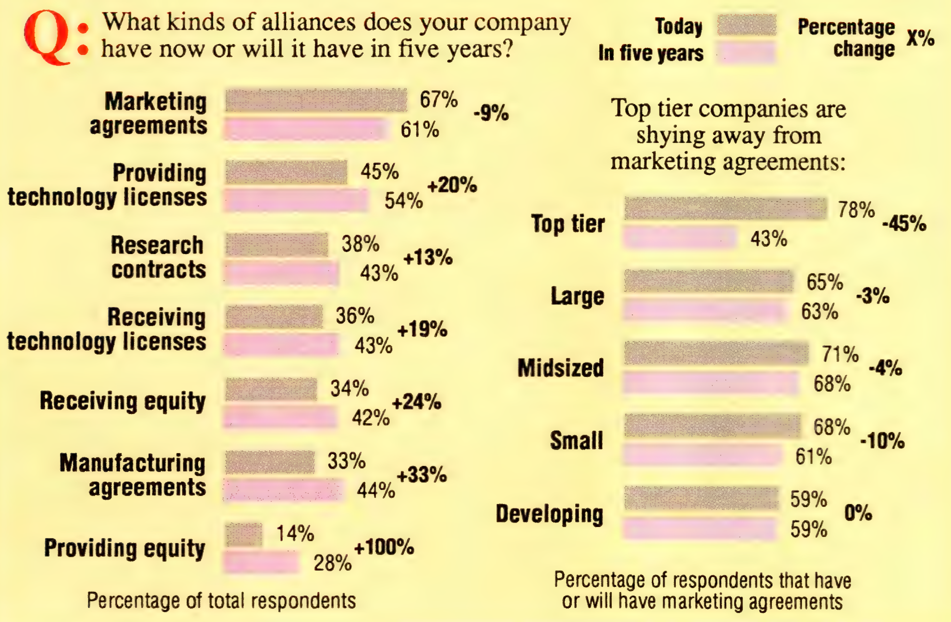
What's causing the shift away from marketing agreements? As globalization increases, U.S. companies expect to gain more expertise in foreign markets and are hoping to take back marketing control. For instance, a relationship with a European distributor might be ideal for the short term, but as the U.S. partner gains confidence and sets up its own European operation, the distribution relationship could be phased out.

Cooperative R&D

Some CEOs argue that U.S. companies should attempt to cooperate more. "The industry has to work together to save itself" against foreign competition, says James Morgan, chief executive of Applied Materials Inc., Santa Clara, Calif., referring to the U.S. semiconductor equipment industry, which largely comprises small companies. That means more mergers and acqui-

CHART 1

MOST TYPES OF ALLIANCES INCREASE IN '90S



CRITICAL ISSUES

sitions, and more cooperative research and development.

Douglas Bartek, vice president and general manager, VLSI Technology

According to the survey, small companies expect to rely more heavily on technology exchanges over the next five years, while large companies will back off slightly (Chart 2).

Evolving standards are one reason for the shift toward more technology alliances. The fight over a generic Unix language has resulted in some interesting bedfellows — Digital Equipment Corp., Hewlett-Packard Co., IBM and others banded together to form the Open Software Foundation Inc. — and the development of an extended industry standard architecture (EISA) in the microcomputer market pits a gang of nine PC makers against IBM.

In aerospace and defense electronics the number of companies providing technology licenses will increase by 62% over the next five years, as a shrinking U.S. defense budget puts pressure on companies to turn to commercial markets and expand overseas. "I think we'll see more and more involvement in international contracts," says Robert Schultz, chief executive of GM Hughes Electronics Corp., "and by the same token, foreign companies will be more involved in this country." GM Hughes and other prime contractors are forming alliances with technology leaders in foreign defense markets in order to go after new business.

The high cost of developing advanced technology is a serious problem for CEOs, especially in the semiconductor business. Developing the next generation of IC process technology means spending upward of half a billion dollars. Technology partnerships are viewed as insurance policies that protect each partner from making poor technology decisions; examples include Texas Instruments Inc.'s deal with Hitachi Ltd. and Motorola Inc.'s relationship with Toshiba Corp. for dynamic RAM technology.

But partnering takes work. "One of the key aspects of any successful partnership is a continued mutual dependence on each other so that one partner doesn't progressively become the dominant player," warns Douglas Bartek, vice president and general manager of one of VLSI Technology Inc.'s divisions. VLSI exchanges ASIC design tools for manufacturing expertise and process technology with Hitachi and N.V. Philips, says Bartek. The best way to avoid problems is to make sure the partnership is well defined at the outset, say many chief executives.

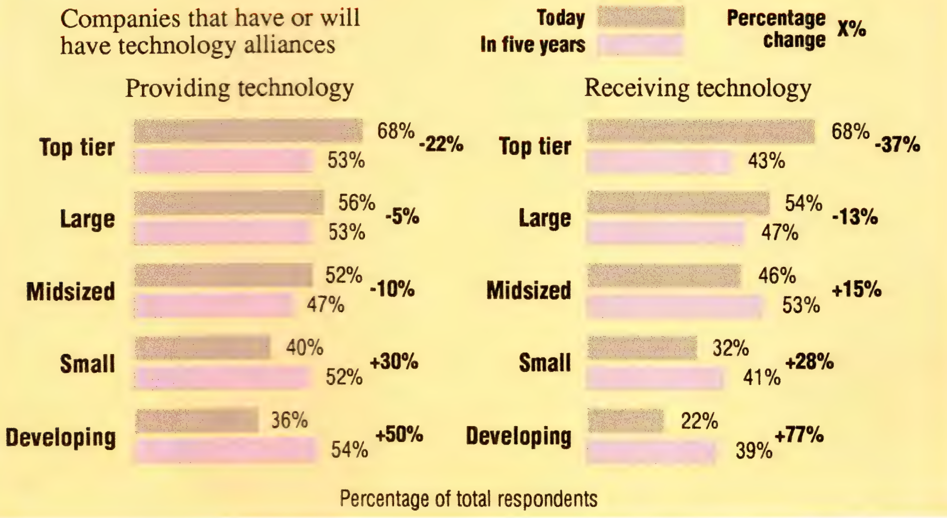
The cost of R&D is a major driver for technology alliances. In total, R&D spending as a percentage of sales will increase by only 3% over the next five years from 9.5% today. By 1995, according to the survey, R&D spending will account for 9.8% of sales. In three market segments — software, industrial electronics and computers and peripherals — R&D spending as a percent of sales is expected to decline. While some of the

"ONE OF THE KEY ASPECTS OF ANY SUCCESSFUL PARTNERSHIP IS A CONTINUED MUTUAL DEPENDENCE ON EACH OTHER SO THAT ONE PARTNER DOESN'T PROGRESSIVELY BECOME THE DOMINANT PLAYER"

VLSI's Douglas Bartek

CHART 2

TECHNOLOGY ALLIANCES FAVORED BY SMALL COMPANIES



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drop can be traced to sales increasing faster than R&D, there will also be a shift away from in-house R&D toward cooperative agreements, say surveyed CEOs.

Closer relationships can reduce R&D costs. For instance, at AST Research Inc., Irvine, Calif., engineering and development spending was just 3.7% of sales in fiscal year 1989, well below the 24% average for the other computer and peripherals makers surveyed. "If we were developing everything ourselves, the R&D percentage of sales would jump up to eight, nine or 10 percent," says Safi Qureshey, chief executive of AST. His company has formal and informal developmental relationships with Microsoft Corp., Intel Corp. and Novell Inc., to name a few.

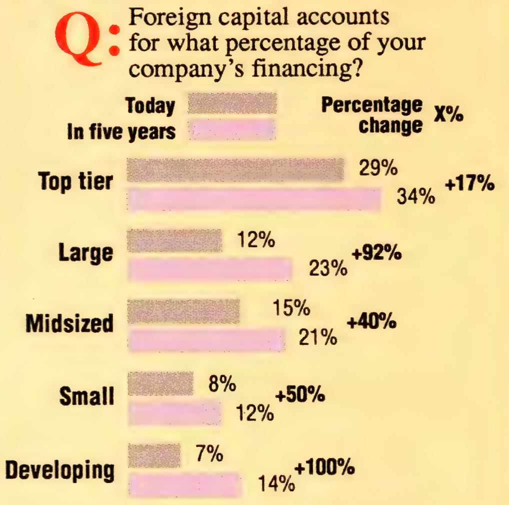
Global manufacturing

The increasing interest in manufacturing alliances is driven by the need to cut costs. Component makers generally lead in the number of manufacturing alliances, now and in predictions for the future. The mushrooming of fabless semiconductor startups, which sprouted in the mid-1980s, is just one example of the trend toward contract manufacturing.

Quality plays a role in the overall trend toward manufacturing alliances, too. As companies face the need for higher quality, they reduce the number of their suppliers. Many companies have established closer supplier alliances as a means of ensuring a steady stream of products that do not require inspection or testing. The paring-down will continue well into the 1990s, say CEOs.

CHART 4

INCREASE IN FOREIGN CAPITAL



Equity role to grow

For some companies, particularly smaller firms, an equity stake is a financial necessity and helps to create a sense of commitment by the partner. For others, mainly larger companies, equity often signals loss of control. "Companies that can operate as two independent firms, who come together because there's a mutual business interest, are stronger alliances than those that are bought by money," argues Winston Hindle, senior vice president at Digital Equipment Corp.

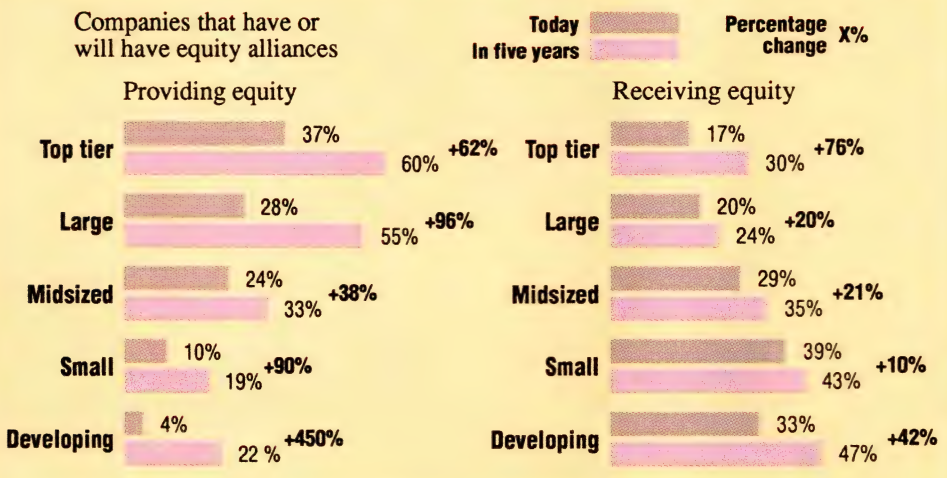
Whatever the preference today, in the 1990s equity will play a bigger role in strategic alliances for companies of all sizes, say those CEOs surveyed. Surprisingly, the biggest equity shakeup will be at the top end of the revenue scale. Of companies with sales between $100 million and $300 million, the number that expect to spend money on equity funding deals will nearly double over the next five years. At the same time, 76% more companies with annual sales of $300 million and above will be on the receiving end of equity deals (Chart 3).

Foreign equity will play an even bigger role in alliances in the next few years. Currently, an average of 3% of the total financing for those companies surveyed comes from foreign alliances, but that figure is expected to double, to 6%, by 1995.

Likewise, foreign capital — including equity, licensing, debt and alliances — will increase from 11% of total capital needs today to 16% in five years, according to the survey (Chart 4). The biggest change in foreign dependence will come from developing companies which will see a 100% increase in foreign capital reliance. Also, companies with sales between $100 million and $300 million expect to increase their reliance on foreign capital as a percent of total capital by 92%, from 12% today to 23% by 1995. ☐

CHART 3

EQUITY COMES FROM BIG COMPANIES



Percentage of total respondents

CRITICAL ISSUES

Electronics and government: A wary association

Government may become more of a friend to industry as both battle foreign competition and try to build a stronger business environment

It's like the weather. Executives in the electronics industry like to complain about the U.S. government. Washington is often ill-informed about electronics, and legislation is frequently counterproductive to the industry, executives say. "The greatest challenge we have is not dealing with foreign competition; I think it's our own government," says one frustrated CEO, echoing the sentiments of many of his peers.

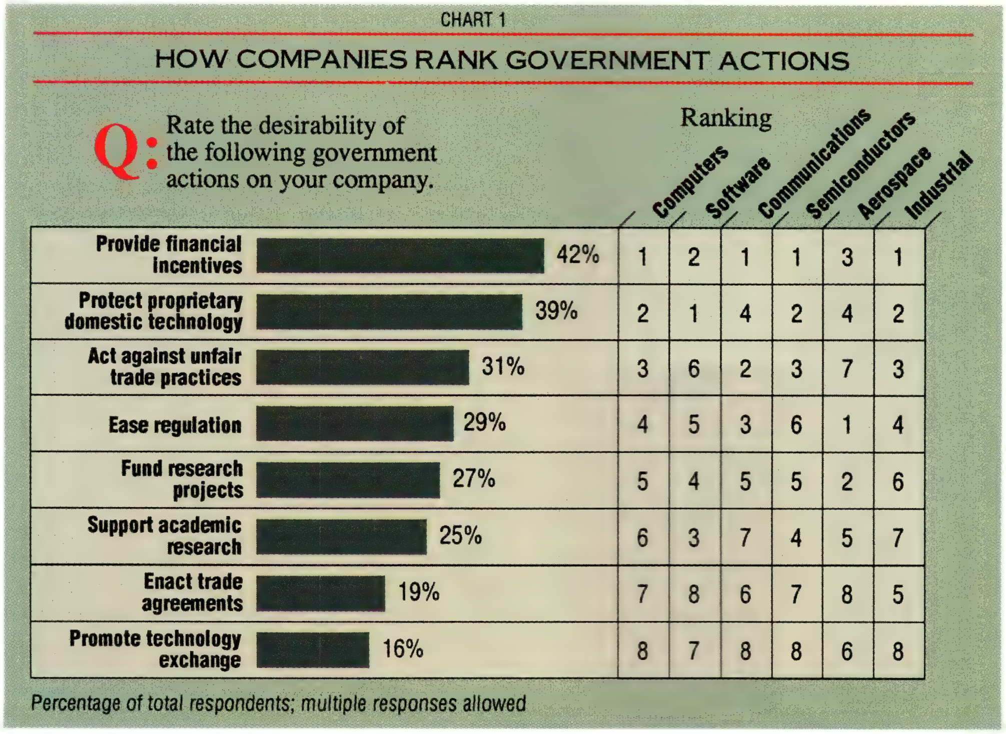
Several electronics trade associations intensively lobby Capitol Hill, but there is a sense that the industry seldom presents a unified front. Congressional sympathy is not high for an industry that is not clear in its political goals. A case in point is the recent failed attempt to form the U.S. Memories consortium. Supporters could not generate enough corporate funding for the dynamic RAM production project, even after having spent months in Washington convincing Congress of its importance. Still, there is a growing awareness among top executives that their views are needed in Washington.

"I think we have an absolute obligation to take a much more proactive stance with government," states F. Gordon Benhard, president and chief executive of Elpac Electronics Inc., Santa Ana, Calif. "If we fail as an industry to do that, then we're going to have some extremely difficult times in the decades to come," he adds. The survey and interviews indicate that executives believe their success in the decade ahead will require closer cooperation between the electronics industry and the federal government.

But what exactly does electronics want from the federal government? At the top of the list, surveyed CEOs believe the government should provide better financial incentives, primarily to lower capital and R&D costs (Chart 1). Capital-intensive companies in industrial electronics, computer and semiconductor markets have the greatest need for such incentives, according to the survey. Many chief executives insist that a new investment tax credit, better research and development tax breaks and low-cost, government-sponsored loans are in order.

CHART 1

HOW COMPANIES RANK GOVERNMENT ACTIONS



Q: Rate the desirability of the following government actions on your company.

Action	%	Computers	Software	Communications	Semiconductors	Aerospace	Industrial
Provide financial incentives	42%	1	2	1	1	3	1
Protect proprietary domestic technology	39%	2	1	4	2	4	2
Act against unfair trade practices	31%	3	6	2	3	7	3
Ease regulation	29%	4	5	3	6	1	4
Fund research projects	27%	5	4	5	5	2	6
Support academic research	25%	6	3	7	4	5	7
Enact trade agreements	19%	7	8	6	7	8	5
Promote technology exchange	16%	8	7	8	8	6	8

Percentage of total respondents; multiple responses allowed

CRITICAL ISSUES

> "THE UNITED STATES GOVERNMENT HAS PLACED EXPORT CONTROLS ON US, WHICH PUTS US AT A COMPETITIVE DISADVANTAGE ON A GLOBAL SCALE"

One reason companies build facilities overseas is that foreign governments provide more investment incentives than the U.S. government. That has implications for U.S. employment and industry growth. Over a quarter of all executives surveyed say that government incentives are the most advantageous factor for building both in the Far East and in Europe (Chart 2).

Winston Hindle, senior vice president of corporate operations, Digital Equipment

Stronger legislation for protecting proprietary domestic technology is also a high priority for CEOs, especially those at software companies. While legislation to protect intellectual property in the U.S. has made great strides in the 1980s, protecting that property in overseas markets remains a major problem. Software piracy in particular is a concern in many Asian markets where enforcement of copyright laws is lax. The feeling by U.S. companies is that legal recourse is not enough and should be enhanced by better U.S. government protection.

Among aerospace and defense electronics companies the top concern is easing government regulations. One example would be to reduce the paperwork involved in selling to the Department of Defense. For instance, the introduction of the computer-aided acquisition and logistics support (CALS) initiative will eventually simplify weapons-systems documentation and cut costs. There is also a trend toward buying more off-the-shelf commercial systems.

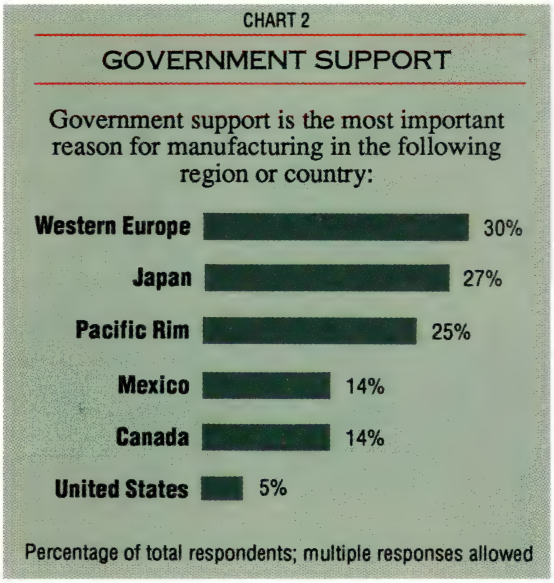


CHART 2

GOVERNMENT SUPPORT

Government support is the most important reason for manufacturing in the following region or country:

Percentage of total respondents; multiple responses allowed

Defense electronics companies also want to see more government funding of research projects. But with cuts in defense budgets over the next few years all but certain, the Defense Advanced Research Projects Agency (DARPA) and other government-funded agencies will have to reduce their spending in the 1990s.

Increased government funding for academic research is a high priority for software companies. That includes high-level language-development projects and other basic research. "I think there has got to be some awareness, sooner or later, that the very basis of our technological leadership will be threatened in the software arena [unless more government support is given]," argues Raymond Noorda, CEO and president of Novell Inc., Provo, Utah.

Even though government has an important role to play in electronics, many chief executives want the government to stay at arm's length. The government would be wise to face up to its own economic problems and focus on broad international issues, say CEOs. While fear of a recession is the top-ranked economic concern for companies, the federal budget deficit is also a major concern (Chart 3). A growing national debt keeps pressure on interest rates and makes U.S. capital more expensive.

Stay at arm's length

Most CEOs do not want the government to erect barriers around their markets. The government's role is not to protect the semiconductor industry, suggests Charles D'Ambrosia, president of Applied Microsystems Corp., Redmond, Wash., "but to deal with the free-trade system on a worldwide basis."

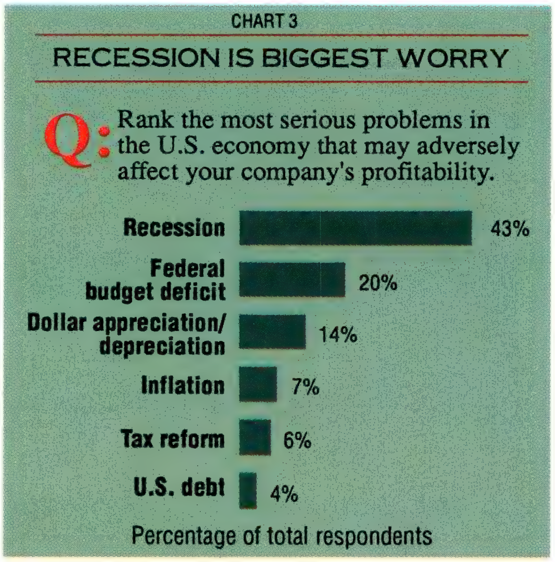
Even though international trade is most important to large companies, especially component and semiconductor equipment makers, nearly a third of all companies surveyed think that the government should get tough with unfair trading practices by foreign competitors. That includes a tougher stance on dumping and retaliation against closed markets.

The government should negotiate trade agreements at the highest levels, industry executives say, beginning with Japan. Western Europe comes in second, followed by the Pacific Rim countries, according to the survey (Chart 4). Half of all companies surveyed believe that their success in penetrating Japan depends on

CHART 3

RECESSION IS BIGGEST WORRY

Q: Rank the most serious problems in the U.S. economy that may adversely affect your company's profitability.



Percentage of total respondents

the government's ability to negotiate tougher trade agreements.

But prying open foreign markets is only one side of the problem. The other side is to do a better job of promoting U.S. exports. "I think that the United States government doesn't yet perceive that technology is, in fact, global, and consequently it has placed export controls on us and on others who have high-technology products, which puts us at a competitive disadvantage on a global scale," says Winston Hindle, senior vice president of corporate operations at Digital Equipment Corp.

The result is that U.S. companies seeking export licenses are forced to spend time and money justifying the export of low-technology products. For many, it's just not worth the effort. In addition, a foreign customer may end up waiting so long for a U.S. product that they ultimately turn to other suppliers. "I think the government is hindering us," says Thomas Brick, chief executive of Keithley Instruments Inc., Cleveland, Ohio.

Part of the problem is that there are too many governmental cooks. Export licensing is the Commerce Department's terrain, but the State Department, the Department of Defense and the Department of Energy all have veto power. Electronics executives want a single body in Washington that can make the decisions and grant export licenses.

"It is still a joke that the day the 80286 [an Intel Corp. microprocessor,] was liberalized by the Department of Commerce, the Secretary of Defense went on TV and said that exporting 286s was comparable to exporting B-2 technology. But the thing is, if you don't get a chance to export those 286s, there won't be any money for B-2s," says Safi Qureshey, chief executive of AST Research Inc., Irvine, Calif.

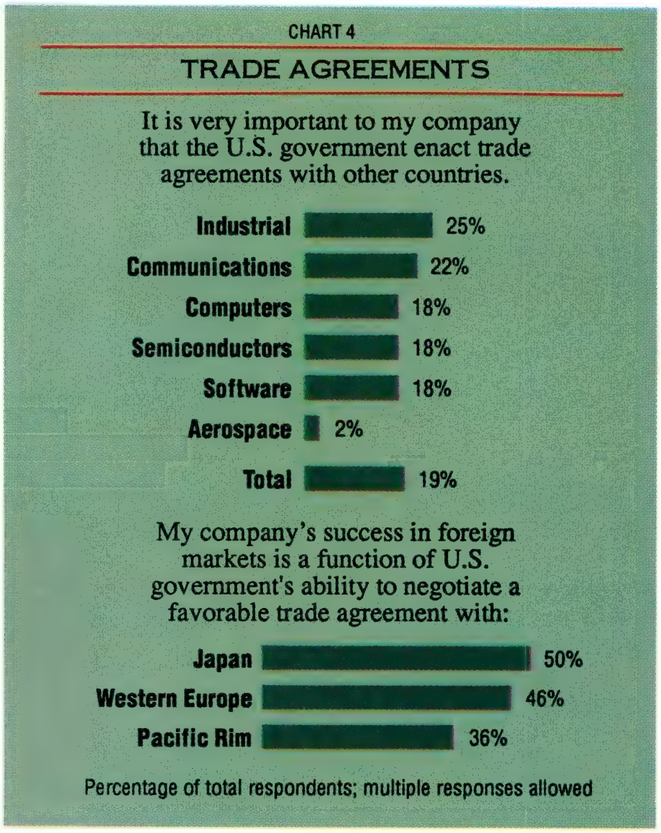
A number of executives point to the need for a government initiative to revive the U.S. electronics industry, especially now that the defense industry is heading south. Since the '60s and '70s — when technology basically started in the military, went to the commercial-industrial market and then to the consumer market — the whole process has been reversed, says T. Kevin Dunnigan, CEO of Thomas & Betts Corp., Bridgewater, N.J. "If you believe that electronics is a strategic industry, then we need a new vision [for consumer electronics]."

The government should start by backing a high-definition television program, say executives. But more is needed. Better patent protection and access to cross-license technology from Japan are examples cited by James Treybig, CEO of Tandem Computers Inc., Cupertino, Calif. "There are patents that Japan won't cross-license, there's the cost of capital, there are lots of things that need to be done," he adds. ☐

SURVEYED CEOS BELIEVE THE GOVERNMENT SHOULD PROVIDE BETTER FINANCIAL INCENTIVES, PRIMARILY TO LOWER CAPITAL AND RESEARCH COSTS

CHART 4

TRADE AGREEMENTS



Percentage of total respondents; multiple responses allowed

What the leaders think

ELECTRONIC BUSINESS senior editor Bruce Rayner and Ernst & Young partners conducted a series of one-on-one interviews with leading electronics CEOs about the challenges their companies face. What follows are question-and-answer excerpts from these interviews.

Compaq keeps an R&D lead

Rod Canion, chief executive, Compaq Computer Corp., Houston, Texas. Compaq has grown its personal computer business through a strategy of lightning-fast time-to-market and top-notch quality.

Q: Where will the fastest growth be in the 1990s?

Canion: We still think that, at least for the next few years, the growth rate in Europe, combined with its size, will be the major factor of [Compaq's] growth, and then probably beyond that — in the four- to eight-year time frame — the Far East will become a bigger factor.

Rod Canion,
Compaq Computer

We have a good position everywhere but Japan, and we're likely to enter Japan at some point in the next decade. It could be [within the next two or three years] or it could be longer. What we're going to do is study the market, come up with a game plan for how to be effective, rather than just sort of leap onshore and see what it's like.

Q: Would Compaq tie up with a Japanese company?

Canion: Not necessarily, no. We're not ruling anything out at this stage, but the factors I've talked about are very general in nature. Depending upon what we conclude is the right approach, my guess is it's fairly unlikely that we would [tie up with a Japanese company], just based on our experience with trying to work with companies.

It's very hard to find a company that is compatible enough to really make it effective. Joining up with a company is a good, quick way of getting a fast start, but the downside typically is what happens in three to five years. And we will tend to be looking at the long term as opposed to the short term.

Q: Your R&D spending is between 4% and 5% of sales. Is that sufficient for the 1990s?

Canion: I think we are in the right range. We may see it evolve upwards another point or something, but we don't anticipate it doubling at all. I think where that question comes from is looking at our competition — they spend a much higher percentage on R&D.

I think, if you look at our product flow, it's obviously not a limiting factor in our ability to create new products. It has to do more with our efficiency and our ability to deliver products quickly. So you don't have to spend as much money on each product. You can get on to the next one much quicker. And that results in a lot of very positive benefits for the company, one of which is a lower percentage of R&D spending.

And that's not the most important, by the way. The most important one is the ability to get out in front of and maintain [the lead over] many of our competitors, from a technology-cycle standpoint.

GM Hughes cuts back defense

Robert Schultz, chief executive, GM Hughes Electronics Corp., Detroit, Mich. GM HE, a GM Corp. subsidiary, is the parent of Hughes Aircraft and Delco Electronics.

Robert Schultz,
GM Hughes Electronics

Q: What are some of the effects of the defense cutbacks on GM Hughes?

Schultz: The defense side of the business, I think, is clearly going to be impacted by the events of the day. But what that's going to result in is almost impossible to say until the smoke clears a little bit here and we can see better into the future. Defense spending itself is bound to decline unless there is a radical turnaround.

At the same time, I think the opportunities for utilizing [defense] electronics technology have great potential in the commercial markets. For example, we were awarded a very major air-traffic-system contract in Canada. That type of thing is going on all over the world: certain commercial airline businesses, the communications and satellite business, intelligent highway programs, environmental monitoring.

Q: Will defense continue to decline as a percentage of your overall business?

Schultz: I think clearly it will, as a percentage. In fact, the companies that can't leverage their technology into useful commercial products are going to suffer.

I think there's going to be a lot of fallout. Primarily among companies that are very specialized and, as a result, may not have the flexibility to shift their technology into some of these other areas. I think it'll primarily be at the second tier. But I wouldn't say that the primes won't be affected, because I think they will be. I just think there's not going to be that many new airplanes, that many major missile systems.

Q: What's the recipe for success for the defense electronics company of the future?

Schultz: It's a combination of strategic alliances. I think we'll see more and more involvement in international contracts. And by the same token, [foreign companies] are going to be more and more involved in this country. I don't think U.S. companies are going to go to Europe and capture major contracts by themselves. I think it's going to be more in the technology sharing and manufacturing capabilities. So I think that the joint ventures, whatever form they take, will be increasingly important, and I think that that's going to be a way of life.

Applied wants cooperation

James Morgan, chief executive, Applied Materials Inc., Santa Clara, Calif. Applied Materials is a leading U.S. maker of semiconductor production equipment.

James Morgan, Applied Materials

Q: What's the role of the U.S. government in electronics?

Morgan: It should be focused on the opportunities where we can make a difference in the future, as opposed to protecting a historically bad situation. [But the government's role] should be transient. You've got to get cooperation or you're not going to be successful. You're not going to be able to compete.

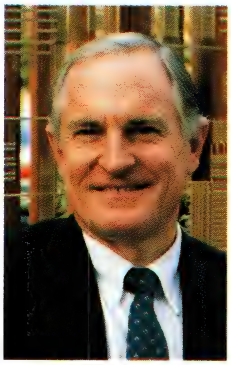
Q: Is Sematech the answer?

Morgan: It's a big help, but everybody gets the idea that it's the solution. Sematech only has $200 million for R&D. We'll spend close to $100 million ourselves, and we don't have enough. It would help if [the government would] give us $50 [million] or $100 million and we'd spend it right.

In the U.S. you have a real problem with the antitrust [laws]. We only look at the U.S. competitors for evaluation, and that's dumb, because almost none of us [have] our primary competitors in the United States. So if you don't look at the antitrust issue on a broad basis, then you're not getting a realistic look at the market.

Intel focuses on the customer

Craig Barrett, executive vice president, Intel Corp., Santa Clara, Calif. Intel, one of the top 10 semiconductor companies in the world. Barrett is the heir apparent to CEO Andrew Grove.



Craig Barrett, Intel

Q: What are the solutions to maintaining a viable semiconductor equipment industry?

Barrett: Sematech's a start. What Sematech can do is foster standards. It can help design, debug, evaluate, proliferate equipment to leverage the whole industry. Sematech's job is to effectively nurture one or two strong players in lithography, furnaces, implant, plasma etch, metal sputtering — those five areas comprise 80% of the capital equipment.

But a lot of it is going to be up to us to buy [from] and support American companies. The problem with the commitment [to buy American] is that it wavers substantially when the vendor doesn't make it, you miss a generation of technology. We were a year late in one of our recent generations of technology because we were on a lithography vendor who didn't make it.

Q: Why is it important to buy from American vendors?

Barrett: I'll tell you why. I was at a SEMI [Semiconductor Equipment and Materials Institute] meeting in Japan and the representative from Nikon stood up and said: "When appropriate, we may even tell our foreign customers about our new equipment." I can't say it any better. "When appropriate," we may hear about their new technology at the same time their Japanese customers hear about their new technology.

A public statement like that to a bunch of U.S. and Japanese folks says it pretty clearly. Nikon happens to be our supplier, and it's nice to know that "when appropriate" they might even tell us about the next generation. I'd rather have someone who's local and committed and, "when appropriate," they might even tell the Japanese about their next generation.

Q: There's been a lot of attention at Intel on manufacturing. Is there much more to be done in that area?

Barrett: We've made a lot of progress. But until you get to 100% yield, there's always ground to play with there. I say that kind of jokingly, but let me give you a simple analogy. If we're projecting out into the second half of

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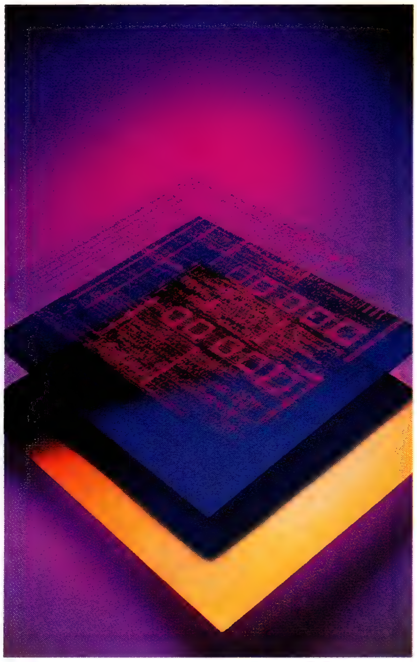

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the decade, we'll be making chips that are one square inch, with 25 [million] to 50 million transistors. Do even the most simple-minded analysis on what defect density is necessary to get any yield on those things, and the number that pops into your head very quickly is zero defect density. A hundred percent yield. So until you get to that, there's a lot of play.

We're not at that level yet, but we think we are making really substantial improvements in the yields of our new technologies coming down the chute. And we track yield and defect density as a function of time, from when we first conceive the technology. The last four generations of technology — each one of them has shaved about a factor of two, in time, to get to the same yield level as the preceding one.

Varian recommends partnering

Thomas Sege, vice chairman, Varian Associates Inc., Palo Alto, Calif. Varian Associates is a diversified technology company specializing in semiconductor equipment, analytical instruments and electron tubes.

Q: Given your company's relationship with Tokyo Electron over the years, are there any lessons to be learned about accessing the Japanese market?

Sege: There are a few success stories where wholly owned subsidiaries of American companies have been successful in Japan, but it is a lot harder to get started there. I would say that, in general, the joint-venture route is a more successful one. You move along a great deal faster.

If you accept that technological competence is worldwide, that technology moves fast, that time to market has speeded up, you are, I think, [better off] working in partnership arrangements than somehow making believe that you can do everything better by yourself.

I think a good bit of the problem that the United States sees in the Japanese market is not as a result of regulations and government decisions; it's more a result of culture. We really don't have a good understanding of the Japanese culture, and yet the Japanese culture affects their relationships [with each other] and causes them to buy Japanese.

They're surrounded by service [in Japan]. Service is tremendous there. When a Japanese manufacturer buys equipment from a Japanese supplier, [the supplier] will have several people living at that plant until the equipment reaches 99% up time. No questions asked.

Not only doesn't that happen [in the United States] because, typically, equipment suppliers can't quite afford to do it, but the semiconductor manufacturers don't want to have the equipment supply people in there.

I think, in partnering, you open your vistas. You see the strength of the other company, you bring your own strength and you have a much better chance of expanding your own [business].

Lessons learned at Ashton-Tate

Edward Esber, chief executive, Ashton-Tate Corp., Torrance, Calif. The software company serves the database PC and server market.

Q: What's your prognosis for the health of the software business in the next few years?

Esber: I think we are seeing, for the first time, a major slowdown in growth of the business [that's being driven by] a lot of confusion in the marketplace. Longer decision cycles, in part driven by that confusion, in part driven by the fact that as personal computers become more of an integral part of the corporate computing architecture, higher levels of people are involved in the decisions. Which usually is a euphemism for longer decision cycles.

And rightly so. No longer are personal computers a separate piece of iron that sits on somebody's desk. People are talking about connecting them up to the minicomputers and the mainframes, and once you do that you're talking about MIS involvement. In the long run, you're talking about senior management problems.

Q: How do you see the computer industry growing over the next three to five years?

Esber: Ultimately, I believe that our industry will become like other industries. It will be cyclical. At some point in time, given the global competitiveness, we can't just buy gadgets because they're great new gadgets. We need technology that we can put to work. And certainly, there's been a big gap and the gap is getting wider between the software industry's ability to write and take advantage of the new hardware platforms and the ability of the hardware business to turn out new boxes rapidly.

Compaq announced the 486 when half the world's still trying to catch up with the 286 and 386 operating systems. So, if I was pessimistic I'd say that this business will end up being like the auto industry or the oil business or any business that has up years and down years.

AST wants export decontrol

Safi Qureshey, chief executive, AST Research Inc., Irvine, Calif. AST is a leading technology-driven microcomputer and add-in board maker.

Q: What are some of the macroeconomic problems the industry faces?

Qureshey: There are some structural issues in the U.S. economy with some of our major trading partners that need addressing. From the high-tech community's point of view, there are the trading restrictions and requirements. We have to comply with the export licenses. Our country is the most restrictive as far as the regulations are concerned compared to many of our trading partners.

As the technology gap between the products that we provide and what other countries provide, shrinks, the [foreign] customers are not willing to wait that long.

We still have inter-agency issues between the State Department, the Defense Department and Commerce Department. It is still a joke that the day the 286 was liberalized by the Department of Commerce, the Secretary of Defense went on TV and said that exporting 286s was comparable to exporting B-2 technology. But the thing is, if you don't get a chance to export those 286s, there won't be any money for B-2s.

Q: How will standards evolve in the next few years?

Qureshey: I think we are adjusting to the new realities in our business, which is more standards and more competition. The trend in standards is really forcing a major dislocation on the traditional players in our industry. We see a major restructuring in the information processing industry. We see a major dislocation in the minicomputer and mainframe segment.

I think it will be traumatic. I think if you look at the layoffs that are going on, that is just the start. We believe that the financial model has changed for our industry, and we really cannot expect to run our businesses on 50% to 60% gross margins.

Tandem learns a new vocabulary

James Treybig, chief executive, Tandem Computers Inc., Cupertino, Calif. Tandem supplies on-line transaction-processing systems and enterprise-wide networks.

Q: What are Tandem's biggest challenges for the 1990s?

Treybig: The most important thing about technology companies is that change is for sure. You must keep forcing your company to change, to move. The '90s will be a time when there continues to be tremendous change toward standards, which puts a burden on companies that continue to search for advantage in standards. Many companies that can't change to the new function are going to have serious problems.

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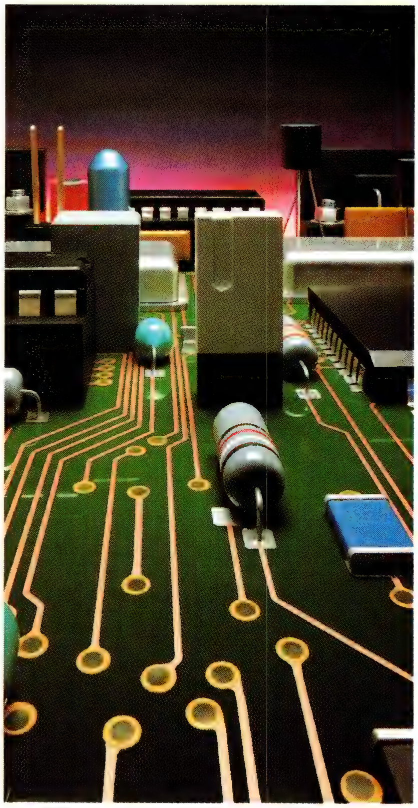

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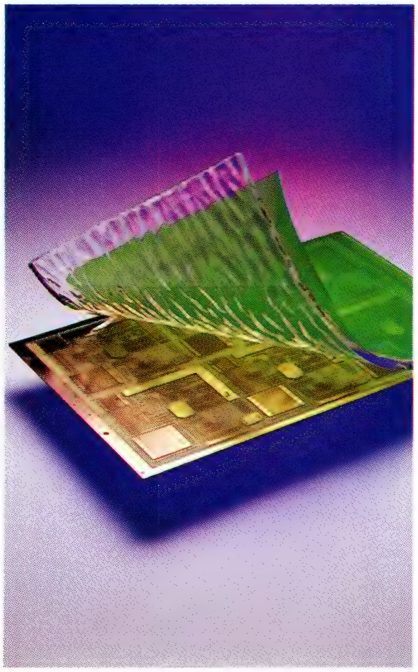

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CHALLENGES FOR THE 1990s

CRITICAL ISSUES

So every decade you have this evolving, changing role of the technology, and you've got to keep moving. The easy part is the technology. The harder part is to move people, to move thought, to move understanding.

Right now, [everybody in the company has] to learn the "words of the '90s" so they can stand up and give a speech on Unix for three minutes. Every person. So it's a systematic way of forcing the understanding of our new direction, continually.

Q: What are the words of the '90s?

Treybig: For Tandem, they are the words of database. They are the words of RISC [reduced instruction set computer] technology. They're the words of new concepts of storage. They're words of tools. Open architectures will let customers use whatever tool they prefer. They're the words of Unix. To succeed, you've got to force an understanding of the new places you're moving to.

Telephones are a part of the world in the future. This connectivity and integration of computer systems — a big part of it is going to be [by] telephone. And we're working hard to be the big winner in that huge market.

Q: How can you balance the introduction of new products with the increasing need to service your installed base? Is there a shift going on?

Treybig: No, we don't have a shift toward service. The key in service is not that it becomes a big part of your business, but it's that you're very careful what [service] business you're in.

What do we want to be known for in service? We want to be known as the people who can support high technology. We want an image of Tandem that [we] support and can service the most sophisticated and newest technology. I think that's good margin.

You have to look at service as part of the product. But all the accountants at Tandem keep wanting to make it separate, and it's dysfunctional. I mean, I just have to keep having energy to go back and fight them because you can't separate [service]. I mean, we may save money and be more profitable in service and as a result lose our basic business which is to have systems that don't fail. But we can't afford that. Other companies can, but we can't.

Mentor acts for better education

Thomas Bruggere, chairman and chief executive, Mentor Graphics Corp., Beaverton, Ore. Mentor is aelectronic design automation company.

Q: Why did you establish a scholarship at Oregon State University?

Bruggere: It's our recognition — and I think it's everybody's in the electronics industry — that it is going to be more and more difficult to get top-quality engineers, because fewer people seem to be going into engineering as a career. More people are going to be needed than are going to be available.

We see it being necessary to try to [provide incentive for] kids to go into engineering. So we've done a couple of things in that regard [besides the university scholarship]: we've adopted an elementary school, and we're working with kids in that school to give them computer-literacy skills. That's the kind of thing that needs to be done. Companies need to get involved in the educational system at different levels.

Q: What are Mentor's biggest challenges for the '90s?

Bruggere: We have to learn to develop more and manage more remote R&D. For example, today 85% to 90% of our R&D is done in Beaverton. It's all within walking distance by one person in several buildings. As we look forward to the 1990s, I believe we're going to see more and more R&D done in other places. I think we're going to see R&D done in Europe, expecially in preparation for 1992. We do some R&D there now. I think the ability to manage those remote activities is going to be really critical for us. ☐

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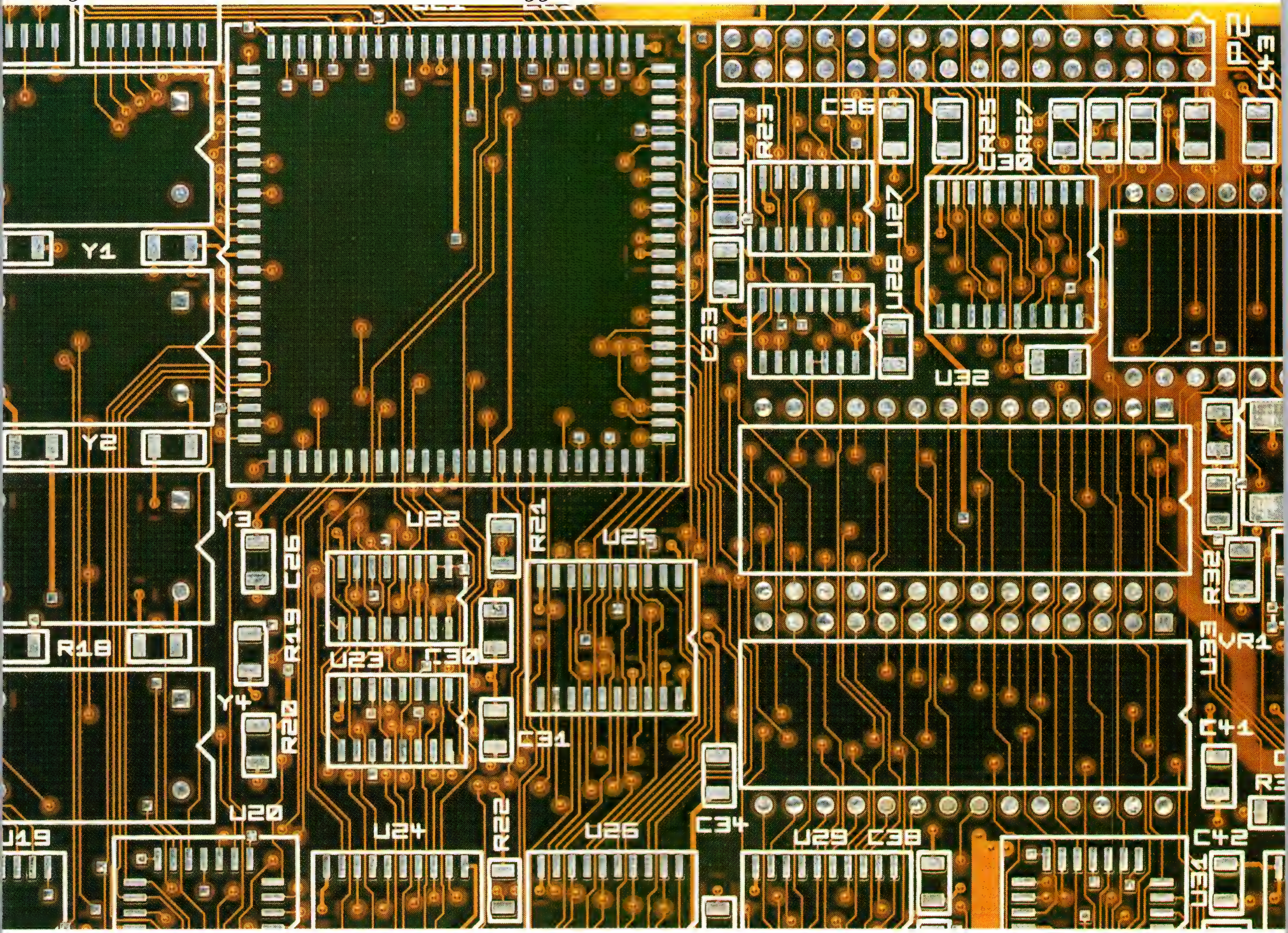

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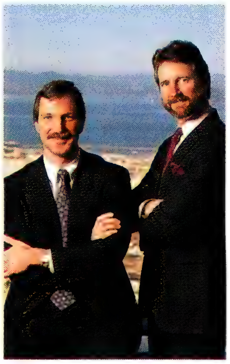
VIEWPOINT

The emerging pyramid of new priorities



Perhaps the one indisputable statement that can be made about today's high-technology world is this: The business environment is becoming increasingly, sometimes frighteningly, competitive and complex. Our domestic markets, within the boundaries of which were once contained both the means of production and the promise of high growth through local consumption, have dramatically and unalterably changed.

New competitors have sprung up around the world, and their ability to challenge U.S. manufacturers is evident — in markets both at home and abroad. The pace of technological development has increased tremendously, driving the need for shorter development cycles and correspondingly shorter periods for payback on capital invested. The unpredictable fluctuations of capital and currency markets, and the resulting impact on capital planning and costs, make smooth and certain growth trends increasingly difficult to achieve.

NEW COMPETITORS AROUND THE WORLD ARE CHALLENGING U.S. MANUFACTURERS AT HOME AND ABROAD

The pace of doing business, due in part to the developments in electronic communications and improved transportation, has accelerated geometrically the geographic expansion of markets and competitors. It is a multifaceted, highly complicated, fiercely competitive world in which today's high-tech businesses are building for the future.

So, do U.S. electronics executives understand this dynamic environment, and are they creating new strategies to compete effectively in this more complicated world? Do they anticipate new needs in the marketplace? Are they focusing on new priorities for the 1990s? We believe the results of our study hold some of the answers to these questions.

The recently completed ELECTRONIC BUSINESS/Ernst & Young survey of CEOs reports what executives think are the critical factors for competitive success, today and into the next decade.

Over one-third of the developing and small electronics companies cited capital availability as the number one issue today. Over one-third of the companies surveyed with revenue of $100 million and over cited technological innovation as their biggest concern today.

But as executives were asked to look into the future, we believe their responses to the question of "the most critical issues facing your company in five years" and the "most important competitive factors in the next five years" suggest a new and promising refocusing on a broader set of objectives for success in the 1990s.

When asked to extend their horizons and address the issues most important for the next five years, CEO respondents emphasized the achievement of "organizational excellence" — which includes customer service, product performance and attracting and retaining key people — as the most critical challenge. This was true of all companies, regardless of size or industry.

Respondents also indicated that organizational excellence was the most important factor for competitive advantage in the next five years. Technological innovation continues to be rated an important factor for success — but in the context of "quality" and "fulfillment of customer needs," rather than as an end in itself. Comments by individual executives reflect a clear and compelling awareness of the need to understand and respond to changing markets and customer needs.

This new set of priorities, we believe, involves three areas of critical focus: product quality and performance; organizational excellence; and customer knowledge and service. Each is important, and all can be balanced and linked together, to create a "pyramid" foundation on which an organization can build its strategic and operational future. We believe it is imperative that electronics companies concentrate on these three essential elements to optimize their long-term return on investment.

THE MOST CRITICAL CHALLENGE IS ACHIEVING ORGANIZATIONAL EXCELLENCE

This triangular model shows the interdependent relationships that must exist among the quality of products delivered, the human systems that make production possible and the market that rewards value received. This "pyramid" may not be as lasting as those built by ancient civilizations, but it could lead us well into the next decade. ☐

Stephen E. Almassy, left, National Director, Computers & Peripherals Industry Services, Ernst & Young

G. Steven Burrill, right, National Director, High Technology Industry Services, Ernst & Young

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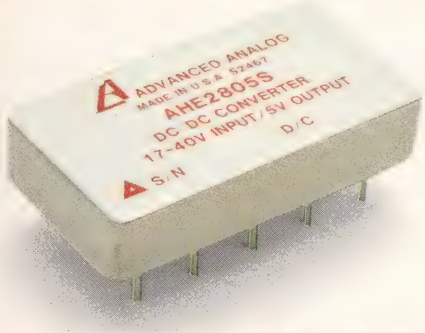

DC/DC Converter

AHE Series	15/20 watts	single/dual
ATW Series	30 watts	single/dual
ATO Series	15 watts	triple
PS Series	27/80 watts	triple

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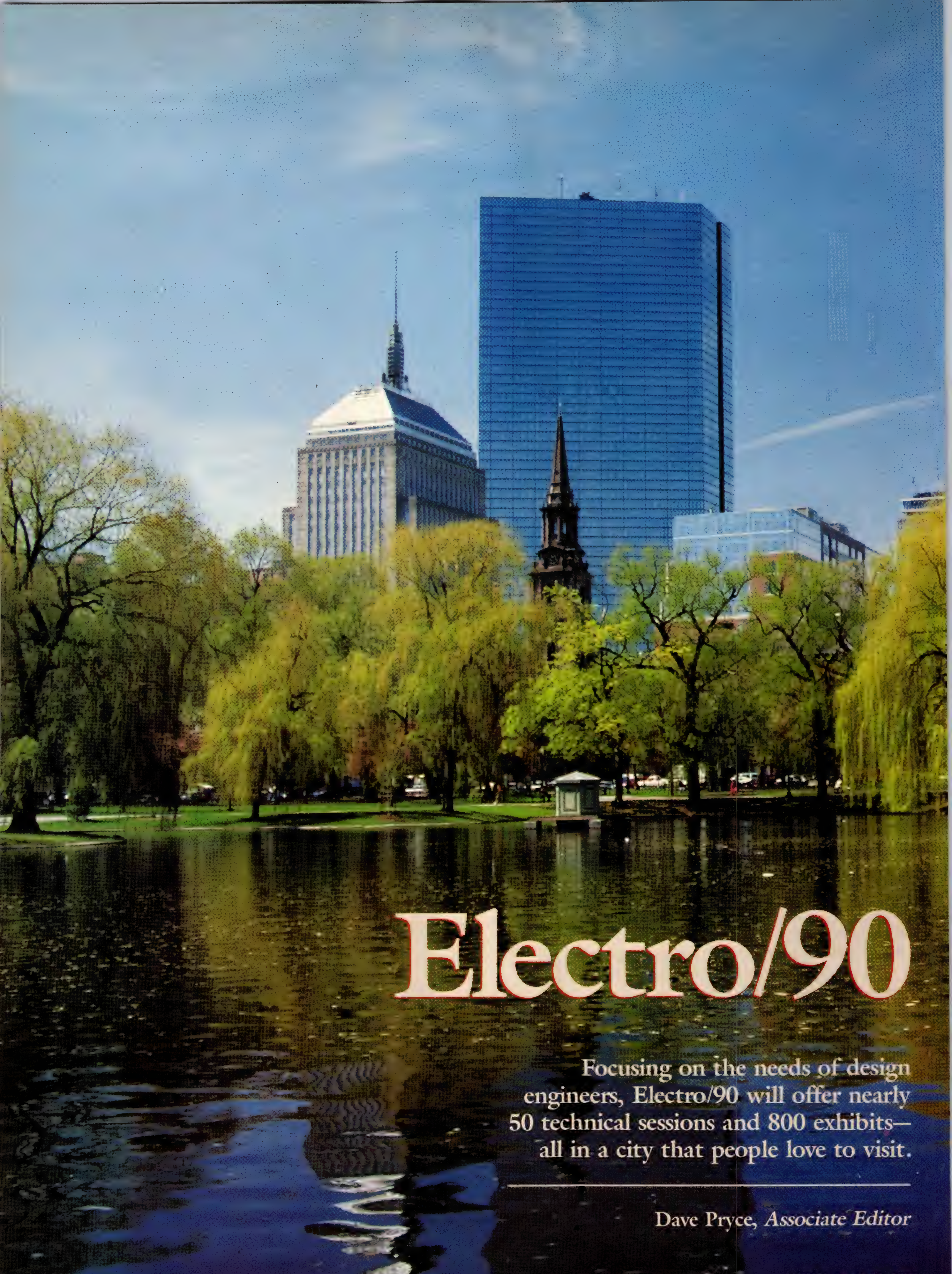

Electro/90

Focusing on the needs of design engineers, Electro/90 will offer nearly 50 technical sessions and 800 exhibits—all in a city that people love to visit.

Dave Pryce, *Associate Editor*

The city of Boston, appreciated for its wide range of good food, entertainment, and historical attractions, will host Electro/90 on May 9, 10, and 11. This year Electro, the eastern United States' largest and most comprehensive exposition for electronic design engineers, expects more than 20,000 attendees. In contrast, only 13,000 visitors filtered through the entrances to New York's Jacob Javits Convention Center for last year's show.

Keynote speaker Thomas H Bruggere, Chairman and CEO of Mentor Graphics Corp (Beaverton, OR), will kick off Electro/90. His address will begin at 9:15 AM on Wednesday, May 9, in Ballroom B at the Hynes Convention Center. In his address, "Electronics in the Global Marketplace," Bruggere will explore many of the challenges now facing US electronics manufacturers. These considerations include planning for the impact of post-1992 European economic integration; surviving a peacetime economy if you're a defense contractor; preparing for the consequences of Eastern Bloc economic and political transformation; and anticipating Japan's changing role in the global market.

The Professional Program, which was developed by engineering managers and consists of nearly 50 sessions (see **table**), will highlight Electro/90. The program will focus on the evolving concept of complete concurrent engineering (CAx), which stresses the importance of integrating all aspects of product development. More than 170 industry experts will participate in program sessions covering 10 subject areas:

- Electronic CAx
- Mechanical CAx
- Manufacturing CAx
- Devices
- Computer-aided software engineering
- Testing
- Quality assurance
- Education
- Marketing
- General.

Wednesday's 9:30 AM tutorial, "EDA evaluation and its impact on the electronics industry," will introduce the CAx focus. This 2-hour presentation, organized by Joseph Cannizaro of Digital Equipment Corp, starts off the professional program with an overview of the CAx sessions and features speakers from the University of California at Berkeley and Cadence Design Systems. The speakers will discuss the evolution of and trends in framework technology, physical design, logic synthesis, verification, and testing.

Other program sessions and tutorials will cover field-programmable gate arrays, the impact of RISC (reduced-instruction-set computer) technology on embedded controllers, ASIC prototyping methods, finite-element analysis, quality and reliability, test and measurement software, and starting a high-tech business.

Engineers attend Electro for the exhibits as well as for the technical sessions. This year, 800 vendors and manufacturers, 120 of which are new exhibitors, will display more than 5000 products and services. Perhaps nowhere else can an engineer gain as much knowledge of available products as in the aisles of these exhibits. Exhibit hours are 10:00 AM to 5:00 PM on Wednesday, 9:00 AM to 5:00 PM on Thursday, and 9:00 AM to 4:00 PM on Friday.

You will find Electro/90 exhibits at both the Hynes Veterans Memorial Convention Center and the Bayside Exposition Center (see **box,** "Boulevards to Beantown"). The Design Automation Center at the Hynes location will contain more than 50 exhibits of CAD/CAE tools used to design and produce integrated circuits and pc boards. Other principal exhibits at the Hynes and Bayside locations will feature test and measurement instruments, semiconductors, passive components, power supplies, and production equipment.

The Hynes Center will also showcase an historical exhibit organized by the Computer Museum, which is located in Boston. The display, which will be open during exhibit hours on all

Photography by Kevin Bryan

three days, will focus on the history of the electronics industry in the Northeast. The exhibit will include portions of MIT's original Whirlwind computer, which was saved from the scrap heap in 1974 by Ken Olsen and Bob Everett; a scale model of the Hollerith Electric Tabulating System, which was first used in the 1890 US Census; and an early Wang word processor.

After a full day of attending technical sessions and visiting the exhibits, you can relax and enjoy the best that Boston has to offer in entertainment and cultural activities. **EDN**

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

Electro/90 professional-program schedule

Wednesday May 9, 1990 9:30 AM to 11:30 AM	**Tutorial 1** EDA evaluation and its impact on the electronics industry	**Tutorial 2** Rapid prototyping technique for printed circuits	**Tutorial 3** VLSI design overview	**Session 1** Starting a technology-based company	**Session 2** Design innovations support test engineering	**Tutorial 4** Using concurrent engineering to document product specifications that SELL!	**Session 3** Developing embedded systems
12:30 PM to 2:30 PM	**Panel Session 4** Digital's ECAD design process	**Session 5** Practical surface-mount assembly	**Session 6** Productivity benefits from new PLD architectures and CAD tools	**Session 7** Making money from software developments	**Session 8** Test and measurement application software for the personal computer	**Session 9** Implementation of concurrent engineering in the mechanical workplace	**Session 10** RISC technology impact on the computer/embedded-controller market
3 PM to 5 PM	**Session 11** CAD framework initiative	**Session 12** Integrating programmable ICs into high-performance manufacturing operations	**Session 13** **This session has been cancelled**	**Session 14** How successful organizations translate customer needs into product responses	**Session 15** Increasing test development efficiency using modular instrumentation software	**Session 16** Electronic packaging	**Session 17** Customer-driven ISDN applications: today's telecommunications reality
Thursday May 10, 1990 9:30 AM to 11:30 AM	**Session 18** Challenges of system-level simulation in the 1990s	**Tutorial 5** Rapid modeling techniques	**Session 19** Field-programmable gate arrays	**Session 20** Starting and financing a high-tech business in today's environment	**Session 21** Engineering for total quality—quality skills for success in today's competitive market	**Session 22** Advances in rapid prototyping	**Tutorial 6** CASE Day 9:30 AM to 10:30 AM Tutorial 6-A Productivity & quality metrics in software engineering
12:30 PM to 2:30 PM	**Session 23** Design synthesis and silicon compilation	**Session 24** Modeling techniques used within Digital Equipment Corp	**Session 25** Advanced logic—new solutions for new requirements	**Session 26** Managing product design data: the challenge of the '90s	**Session 27** Reliability in perspective, covering the focus and the trends in reliability	**Session 28** Finite element analysis	11 AM to 12:30 PM Tutorial 6-B CASE in a real-time embedded-systems environment
3 PM to 5 PM	**Session 29** Can EDIF, IGES, and VHDL support an integrated design system?	**Session 30** Advanced silicon processing for the 1990s	**Session 31** VLSI content-addressable memory applications range from pattern recognition to LAN bridging	**Session 32** Critical marketing issues in the 1990s	**Session 33** Supportability—a necessary design consideration		1:30 PM to 2:30 PM Tutorial 6-C Integrated CASE environments 3 PM to 5 PM Tutorial Panel 6-D CASE in the 90s
Friday May 11, 1990 9:30 AM to 11:30 AM	**Tutorial 7** Fugure trends in CAx framework at Digital		**Session 34** ASIC prototyping alternatives for system-level design validation		**Tutorial 8** Environment stress screening	**Session 35** Women in engineering	**Session 36** From pencils to CAx
12:30 PM to 2:30 PM			**Session 37** Coping with timing problems in the 1990s—new tools and techniques		**Session 38** The software side of PLD design technologies	**Session 39** Evolving fiber-optic LAN	

Boulevards to Beantown

As is customary when Electro comes to Boston, exhibits will be on display at two locations—the Hynes Veterans Memorial Convention Center in downtown Boston and the Bayside Exposition Center on Boston Harbor. Although you might encounter traffic-related delays, getting to either location is relatively simple.

You'll find the Hynes Convention Center at 900 Boylston St in the Back Bay section of Boston. Public parking is available at the adjacent Prudential Center and at nearby Copley Place.

From the west, you can reach the Hynes Convention Center by taking the Massachusetts Tpk (Rte 90) to the Prudential Center exit.

From Logan Airport and points north, take Rte 93, which runs north and south through Boston, to Storrow Dr; exit at Copley Square, turn right on Beacon St, left on Massachusetts Ave, and left on Boylston St.

From the south or east, take the Southeast Expressway (Rte 93/3) to the Massachusetts Ave exit. Continue on Massachusetts Ave to Boylston St.

Located on Boston Harbor in South Boston, the Bayside Exposition Center offers public parking for 1900 cars. You can reach Bayside by taking exit 15 from Rte 93/3. From the west, take the Massachusetts Tpk east until it merges with the Fitzgerald Expressway and Rte 93 in Boston; follow the signs to Rte 93 South.

If you'd rather let someone else do the driving, shuttle buses will operate between three suburban locations and the event sites. The buses will leave periodically between 7:30 and 9:00 AM Wednesday through Friday and will return Wednesday and Thursday from 4:00 to 5:30 PM and Friday from 3:00 to 4:30 PM.

The suburban shuttle locations for the north are the Showcase Cinema in Middlesex and Canal Park in Woburn; for the west, Shoppers World in Framingham; and for the south, Howard Johnson at the South Shore Plaza in Braintree.

Shuttle buses will also operate continuously between the Hynes Convention Center and Bayside Exposition Center, beginning at 7:30 AM each day and ending 30 minutes after the exhibits close.

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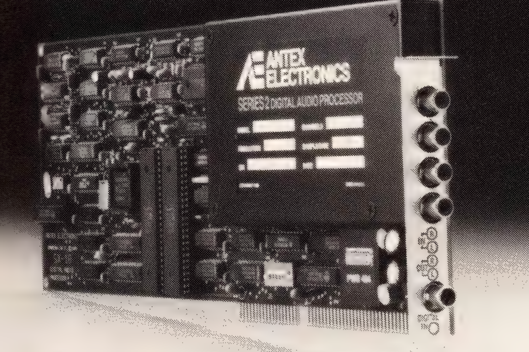
CIRCLE NO. 66

AUDIO PRO



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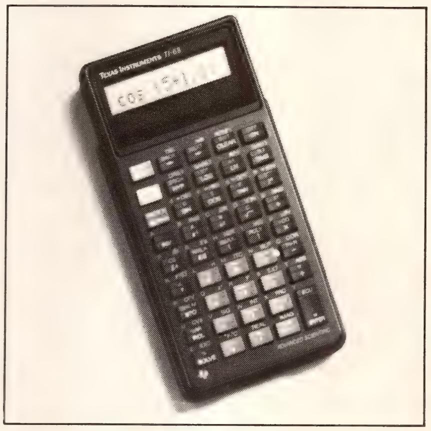
CIRCLE NO. 67

Calculator solves simultaneous equations and evaluates complex numbers



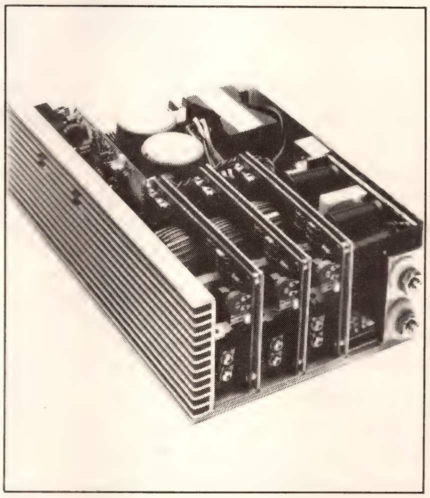
The 254-function TI-68 advanced scientific calculator solves as many as five simultaneous equations with real or complex coefficients, and it features a plain-English prompting system, which guides you through each equation. The unit also evaluates 40 complex-number functions, from simple arithmetic to advanced trigonometry. As you enter complex numbers using either polar or rectangular coordinates, the display simultaneously shows real and imaginary parts.

The unit provides last-equation recall and replay; has 36 memory registers to which users can assign alphanumeric names; performs as many as 440 steps of formula programming for as many as 12 formulas; performs Simpson's-rule integration; executes 1- and 2-variable statistical functions including linear regression and trend analysis; and performs number-based conversions and Boolean-logic operations. The calculator executes 18 other conversions including polar/rectangular, English/metric, and angular measurements (degrees, radians, and grads).

The unit features 44 keys and an LCD that displays as many as 12 alphanumeric characters and scrolls to show equations as long as 80 characters. The LCD is recessed and tilted to reduce glare. The TI-68 measures 6.0×3.0×0.6 in., weighs 4.5 oz, operates on one lithium battery, and features automatic power-down. $65.

Texas Instruments, Consumer Relations, Box 53, Lubbock, TX 79408. Phone (806) 747-1882. Booth No. 1151. **Circle No. 700**

Open-frame switching power supplies feature 400 to 750W ratings



The Moduflex M series of open-frame switching power supplies features power densities of 6W/in.^{3} at an ambient temperature of 50°C. The modular system reduces manufacturing to simple submodules that support high-volume production with delivery times of two weeks or less.

The supplies, which use current-mode control and a 120-kHz MOSFET design, achieve a typical efficiency of 80%. Input modules have ratings of 400, 500, 600, and 750W; output modules have nominal power outputs of 75, 150, 500, and 750W. Standard features include TTL-compatible system inhibit and isolated, quasiregulated 12V fan output. Options include an autoranger function, which provides automatic operation at specified input ranges without strapping; a power-fail monitor; independent pilot bias; and covers for the fan or the complete assembly.

The modules also feature undervoltage, overvoltage, overload, and short-circuit protection. The units' thermal shutdown cuts off power in the event of a local overtemperature condition; the devices reset automatically when the temperature returns to normal.

The power supplies feature line regulation of ±0.1% or ±5 mV, load regulation of ±0.2% or ±10 mV, and ripple and noise of 1% or 100 mV p-p over a 20-MHz bandwidth. From $478.

Deltron Inc, Box 1369, North Wales, PA 19454. Phone (215) 699-9261. Booth Nos. 2425, 2427. **Circle No. 701**

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CIRCLE NO. 68

External Affairs and
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Newer, faster logic families require controlled impedance cable assemblies. Designed for high-speed performance. Engineered for controlled impedance and propagation rate. And manufactured for absolute conformity to specifications.

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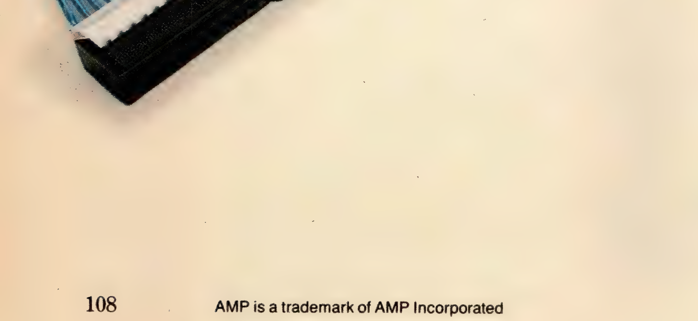

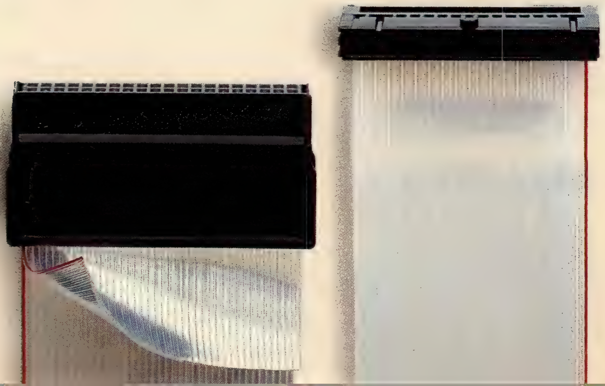

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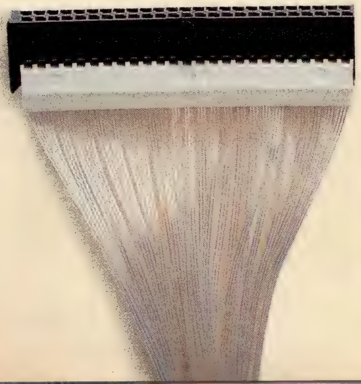
$t_r = 3$ns, ordinary cable assemblies.

with you early in the design stage to provide an optimum solution to your requirements. We help you determine the characteristics for impedance and propagation velocity that you need to match timing requirements, and the crosstalk figures you have to meet.

We engineer and manufacture controlled impedance assemblies in a way you'll especially appreciate. Our manufacturing facilities are unmatched in the industry. Every assembly is individually inspected and 100% electrically tested. All work is part of the overall statistical process control system at AMP, and comes under our corporate-wide quality program.

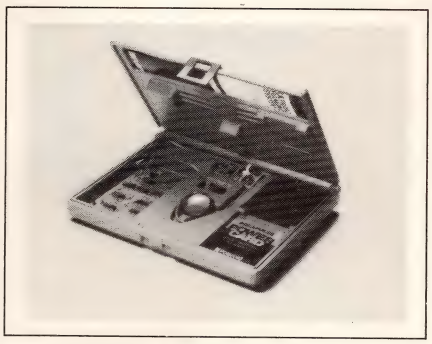
For technical literature and more information on high-speed controlled impedance assemblies—for logic rise times from 3ns down to the sub-nanosecond range—call 1-800-522-6752. AMP Incorporated, Harrisburg, PA 17105-3608.

AMP Interconnecting ideas



CIRCLE NO. 69

Electro/90 Products

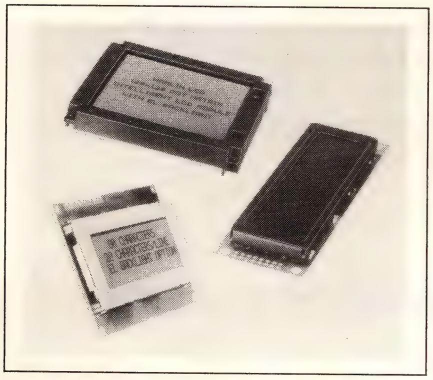


Ultrasonic Ranging System

Using an electrostatic transducer to generate high-frequency sound and convert its reflection to electrical signals, this ultrasonic ranging system detects objects at distances of 10.8 in. to 35 ft. The system, which can detect objects as sound-absorbing as foam rubber and as thin as a flower stem, is accurate to ±0.125 in. at distances to 10 ft and to ±1% of the reading as far as 35 ft away. The transducer, which is compact enough to fit into a camera, suits robotics, electronic games, and vehicular collision-avoidance systems. Designer's kit, $165; OEM kit, $99. You can also buy individual components.

Polaroid Corp, Ultrasonic Components Group, 119 Windsor St, Cambridge, MA 02139. Phone (617) 577-4681. Booth Nos. 5022-5024.

Circle No. 702

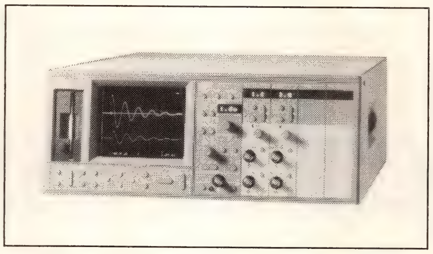


Dot-Matrix LCD Modules

A family of more than 20 standard LCD modules provides a variety of sizes, display styles, backlighting, and mounting configurations. Some of the modules incorporate state-of-the-art supertwist LCDs and LED backlighting. The dot-matrix modules are available in a range of alphanumeric styles from 8 characters×1 line for $15 to 20 characters×4 lines for $138 (100). The intelligent graphics modules come in matrix configurations from 240×64 pixels for $180 to 480×128 pixels for $275 (100). All modules have CMOS circuitry and easily interface with the host system's logic. Custom modules are also available.

Hamlin LCD Div, Standish Industries Inc, W7514 Hwy V, Lake Mills, WI 53551. Phone (414) 648-1000. Booth No. 8.

Circle No. 703

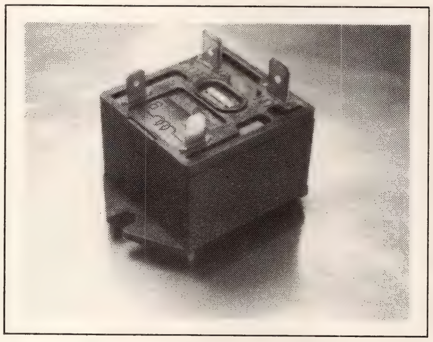


High-Resolution Digital Oscilloscopes

The 410, 410E, 420, and 420E digital oscilloscopes offer high resolution with 12-bit digitizers that operate at 1M sample/sec. Suitable for materials testing, electrical power analysis, electromechanical testing, and physiological measurements, the oscilloscopes also perform stand-alone test automation in factory-floor applications. The instruments are available in 2- and 4-channel models and feature 64k or 256k bytes of memory per channel, a built-in MS-DOS disk drive, an optional hard disk and 44M-byte removable cartridge, and IEEE-488 and RS-232 interfaces. Built-in waveform processing includes FFT and averaging modes. From $10,900.

Nicolet Test Instruments, 5225 Verona Rd, Madison, WI 53711. Phone (800) 356-3090; in WI, (608) 273-5008. Booth Nos. 1420-1424.

Circle No. 704

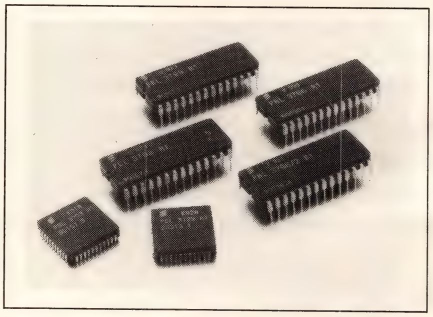


Compact 30A Relays

The 1735 series of compact relays is UL- and CSA-rated for 30A at 240V ac, and it comes with quick-connect or pc-board terminals. The silver-tin-indium contacts are single form A (spst-NO) rated for 100,000 operations min at the rated load. Contact resistance is 30 mΩ max. The relays are available in dc coil voltages of 6, 9, 12, 24, and 48V and operate from −30 to +60°C. Dielectric strength is 1200V rms between open contacts and 3000V rms between the coil, contacts, and field piece. Delivery, stock to eight weeks. $3 (1000).

Guardian Electric Manufacturing Co, 1425 Lake Ave, Woodstock, IL 60098. Phone (815) 337-0050. Booth Nos. 5536-5538.

Circle No. 705



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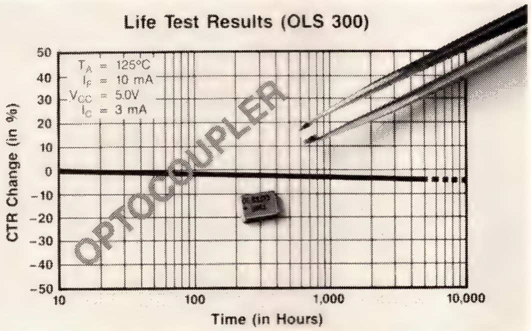
...in small packages.



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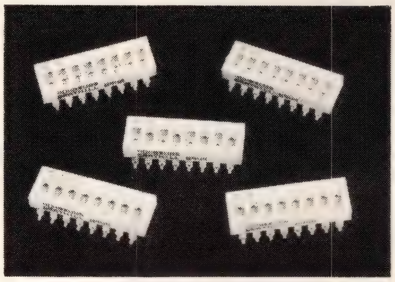
Fax: (408) 946-1960

CIRCLE NO. 72

reduces power consumption. The series offers several battery-feed options including resistive feed (PBL-3799); resistive feed with current limiting (PBL-3796 and PBL-3796/2 for voltages of −63V and −48V, respectively); and constant-current feed (PBL-3798). All parts are available in 28-pin ceramic DIPs; the PBL-3798 and PBL-3799 are also available in 44-pin quad ceramic packages for surface-mount applications. From $11.95 (1000).

Ericsson Components Inc, 403 International Pkwy, Richardson, TX 75081. Phone (214) 480-8300. Booth Nos. 3312, 3314.

Circle No. 706



Surface-Mount DIP Switches

The 90H series of DIP switches is compatible with the 260°C solder-reflow temperatures used in board assembly. The 8-station surface-mount switches use a spring-and-ball contact system, which provides high contact pressure to ensure reliable operation despite infrequent use. This system also provides protection from shock and vibration. $2.20 (100).

Grayhill Inc, 561 Hillgrove Ave, LaGrange, IL 60525. Phone (708) 354-1040. Booth Nos. 4137-4139.

Circle No. 707

Strain-Gauge Signal Conditioner

A complete strain-gauge signal-conditioning system on a card, the Model 160MK Bridgesensor includes a bridge power-supply regu-

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CIRCLE NO. 74

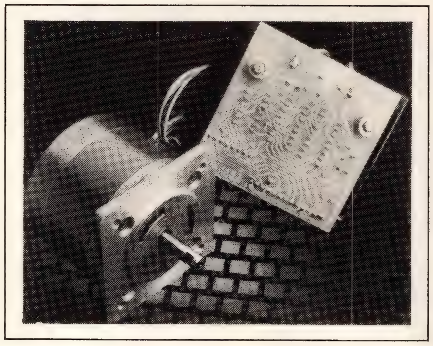
lator, a differential amplifier, and an active filter. A switch-position chart on the card shows you how to select 10-, 100-, or 1000-Hz corner frequencies for the unit's 2-pole active filter. Remote sensing eliminates errors caused by long leads. A trimming potentiometer adjusts the bridge excitation voltage between 4 and 12V dc. The regulator can supply 0 to 100 mA of current. The instrumentation amplifier features a voltage gain from 2 to 5000, common-mode noise rejection of 140 dB, and a unity-gain bandwidth of 25 MHz. The 160MK provides adjustments for coarse and fine gain and input and output offset. Additional features include a bridge-balance potentiometer, bridge-completion resistors, and a connector with built-in card guides. $215.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (800) 542-3355; in CA, (415) 932-3911. Booth No. 5036.

Circle No. 708

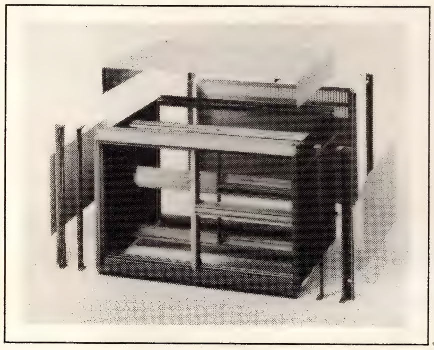
Brushless DC Motor

This size-23 brushless dc motor is available with a low-cost bipolar IC drive that improves efficiency and requires minimum pc-board space. The motor, which operates at speeds to 10,000 rpm, is available with input voltage ratings from 10 to 45V. Other voltages are available with discrete-component drives. Starting torque is 15 oz-in. max. The motor's brushless design and ball-bearing construction enhance product life. Options include speed control, braking, reversibility, current limiting, and special mountings and shaft configurations. $50 to $100 (OEM qty).



Eastern Air Devices Inc, 1 Progress Dr, Dover, NH 03820. Phone (603) 742-3330. Booth No. 5249.

Circle No. 709



Card Case Provides Mounting Options

The Cardpac case is an enclosed tabletop case that is compatible with EIA RS-310 standards for 19-in. rack mounting. Suitable for VMEbus, Multibus-II, and µP applications, the case meets IEEE-1101 high-density packaging standards. When it is cabinet mounted, the unit improves airflow characteristics. $165 (3U high) to $300 (7U high).

Schroff Inc, 170 Commerce Dr, Warwick, RI 02886. Phone (401) 732-3770. Booth No. 2520.

Circle No. 710

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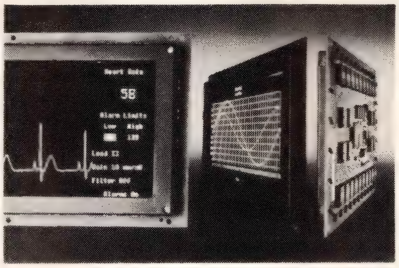
Performance comparison based on OrCAD PCB II as of 1/1/90.

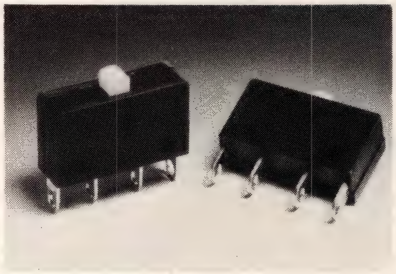
CIRCLE NO. 75

Flat-Panel Displays



Using dc electroluminescent technology, the 640×200-pixel flat-panel displays slash power requirements to 6W, making the displays useful for battery-operated equipment. They are available in 6.67×7.7- and 3.9×8.9-in. panel sizes and are rated at greater than 10,000 hours of operation with no loss of light output. Because the displays don't need a circular-polarizing filter, their brightness is said to exceed that of equivalent ac thin-film electroluminescent displays by approximately three times. $346 (10,000).

Cherry Electrical Products, 3600 Sunset Ave, Waukegan, IL 60087. Phone (708) 360-3413. Booth No. 4123. **Circle No. 711**



Type-16 Switch With Gold Crosspoint Contacts

Featuring the dependability and longevity of the butterfly snap-action mechanism combined with gold crosspoint contacts, this type-16 switch provides highly reliable, logic-level switching. The spdt switch is available with either Form C or Form Z contact arrangements. It is rated at 0.1A at 125V and 1.0A at 30V. Two- and 3-pole versions are available as are a variety of terminal types and actuators. Form Z spdt version, $6.81 (1000). Delivery, 10 to 12 weeks ARO.

ITW Switches, 6615 W Irving Park Rd, Chicago, IL 60634. Phone (312) 282-4040. Booth No. 3213. **Circle No. 712**

Compact Mechanical Rotary Encoders

Series 500 rotary encoders measuring 0.830×0.830×0.343 in. facilitate panel mounting in limited space. The manually operated encoders provide a 2-bit gray code for relative-reference applications and

Text continued on pg 122

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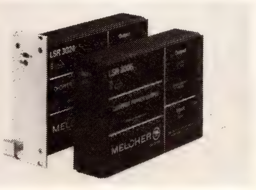
CIRCLE NO. 76

AC-DC SWITCHERS MEET IEC601.1 LEAKAGE

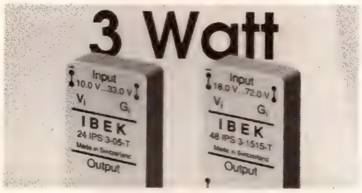
The LSR/USR series of 20 and 30 watt power supplies, along with the 50 watt LM units, are now available with reduced leakage currents for Medical instrumentation. By specifying option 'M', the 20/30 watt units are suitable for all types of apparatus, including direct heart contact, while the LM series can be used for equipment with direct patient contact. Also standard is 4000 Vrms isolation from input to output, and RFI levels below level B (VDE 0871). For more information on high efficiency medical power supplies, contact Melcher at (508) 881-4715 or FAX (508) 879-8669, and ask for application note #3.



CIRCLE NO. 77

DC-DC'S COVER 24/48 VDC TELECOM SYSTEMS

The 48ITS2 and 48IPS3 families of DC-DC converters offer 4:1 input ranges, 18…72 VDC, to cover nominal 24 and 48 V systems with the same unit. Providing up to 3 watts of output power in single or dual output versions of 5, 12 and 15V, these devices keep 75…80% efficiency, while providing complete protection against overvoltage and short circuit conditions. Also standard in these 24 and 40 pin DIP's is a remote shut-down pin for added versatility. For other solutions under 6 watts, including ISDN devices, contact Melcher at (508) 881-4715 or FAX (508) 879-8669, and ask for information on the IBEK family.



CIRCLE NO. 78

DC-DC CONVERTERS FOR LOCOMOTIVE/TRANSIT APPLICATIONS

The tough requirements of the transportation industry demand tough DC-DC converters. Melcher has developed the BM/CM/DM series with 5:1 input ranges of: 14…70, 28…140, and 44…220 Vdc to accept 36, 72 and 150 Vdc nominal systems. In addition to their British Rail Board approval for surge and transient protection, these units also meet MIL STD 810D for shock and vibration withstand, and can provide up to 3 outputs at 50 watts, with a no derating temperature range of -40…71°C (ambient) and -40…95°C (case). For more information, contact Melcher at (508) 881-4715 or FAX (508) 879-8669, and ask for application note #4 on railway approvals.

CIRCLE NO. 79

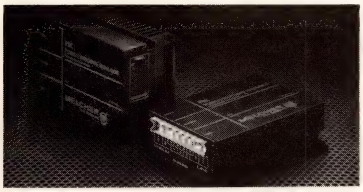
HIGH REL SWITCHERS FOR CONTROLS SYSTEMS

For applications requiring high reliability or precise performance characteristics, Melcher offers the LM series. Providing up to 3 fully regulated outputs at 50 watts, from an input range of 85…264 Vac. These units are well suited to 115v/400Hz airborn instrumentation systems, critical in-line process control equipment, or high reliability SCADA systems, among others. These units are suitable for 3U rack or chassis mounting and possess MTBF's of up to 143,000 hrs per MIL STD 217E. For more information on power supplies that work when others won't, contact Melcher at (508) 881-4715 or FAX (508) 879-8669.

CIRCLE NO. 80

HIGH EFFICIENCY CONVERTERS FOR AGV/ROBOTIC SYSTEMS

For battery based, Automatic Guided Vehicles and Robotic systems, Melcher offers the PSR and PSK series of high efficiency, wide input range, DC-DC converters. Both families provide single output units in 5,12,15,24 and 36 V versions at up to 12 (PSR) or 25 Amps (PSK) with inputs as wide as 8…80 Vdc. Each unit offers full output power from -25…71°C ambient, excellent shock and vibration immunity, and small package sizes. Options include output voltage trim (0…100%), –40°C operation, and input voltage monitor. For more information, contact Melcher at (508) 881-4715 or FAX (508) 879-8669 and ask for application note #2.



CIRCLE NO. 81

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MELCHER, INC. 200 Butterfield Drive, Ashland Massachusetts 01721
Tel. 508-881-4715 Fax 508-879-8669

CIRCLE NO. 82

a 4-bit gray code for absolute-reference applications. The encoders have as many as 36 electrical and mechanical detented positions and a rotational life of more than 100,000 revolutions. The units have an operating temperature range of −15 to +85°C; a contact rating of 250 mA at 28V; an operating resistance of 5Ω max closed and 100 kΩ open; and dual construction with concentric shafts. The devices also feature silver-plated terminals. From $1.55 (1000).

Clarostat Mfg Co Inc, 1 Washington St, Dover, NH 03820. Phone (603) 742-1120. Booth No. 5627. Circle No. 713

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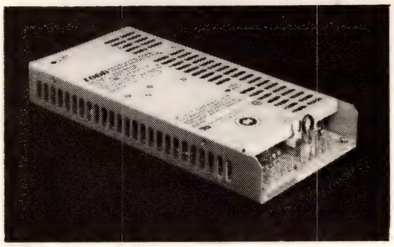
CIRCLE NO. 83

Ceramic Chip Capacitor

The 1206 ceramic chip capacitor, which features the company's X7R dielectric, provides resistance to thermal-shock cracking in wave- or reflow-solder assembly operations. The 1206 chip has a capacitance of 100,000 pF and a tolerance of ±20%. $0.07 (10,000).

Kemet Electronics Corp, Box 5928, Greenville, SC 29606. Phone (803) 963-6348. Booth Nos. 5712, 5714. Circle No. 714



Low-Profile 160W Switching Power Supply

Targeted for hard drives and removable hard-drive systems, the MLP-162-0512 160W switching power supply comes in an 11×5.25×1.6-in. package. The unit has a main output of 5V at 12A and a second output of 12V at 8A max with a 12A peak rating for 16 msec. Both outputs provide a ±10% adjustment. The power supply, which needs 30 cfm of forced air to achieve its full output power ratings, features overload and overvoltage protection and automatic thermal shutdown. The unit has a typical effi-

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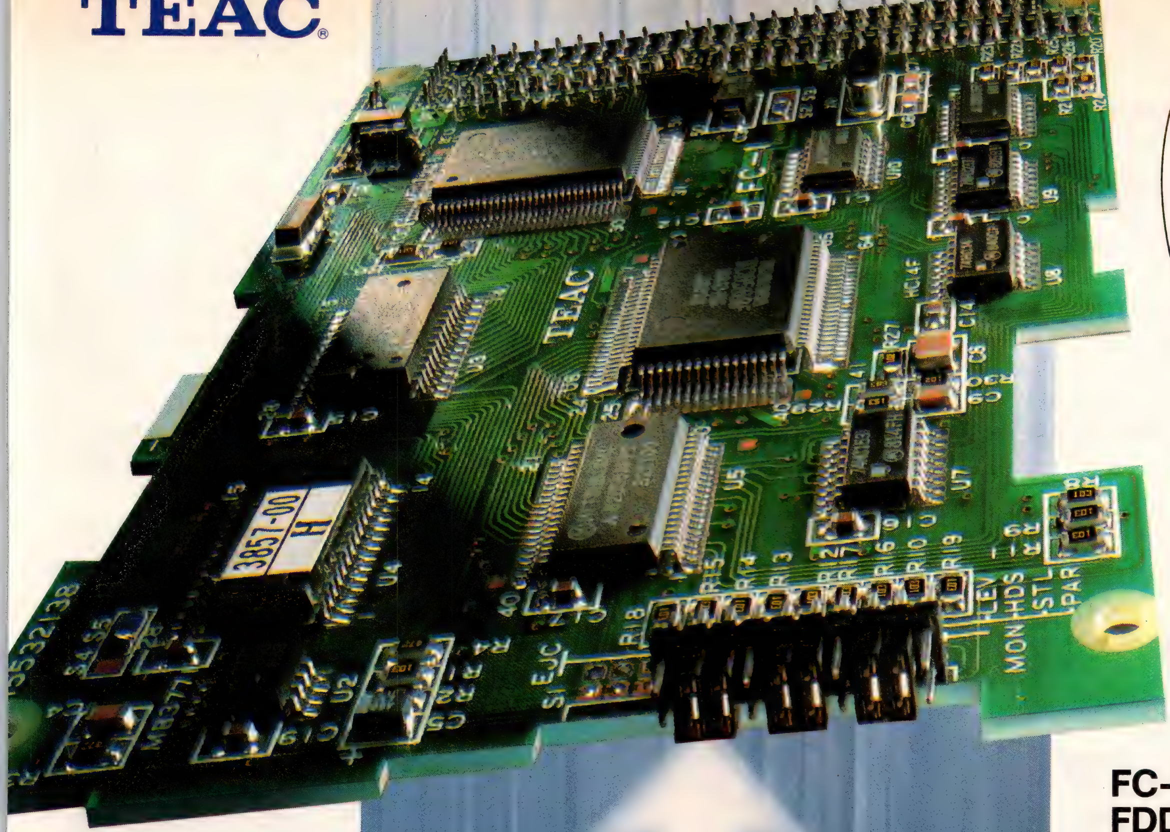

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TEAC FDDs with built-in FC-1 SCSI controllers, including the FD-235HS and FD-235JS, are also available.

CIRCLE NO. 85

FD-235J
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ciency of 75%; operates from 0 to 50°C; and meets UL-478, CSA-22.2, VDE-0806, and IEC-380 specifications. $215 (100).

Todd Products Corp, 50 Emjay Blvd, Brentwood, NY 11717. Phone (800) 223-8633; in NY, (516) 231-3366. Booth Nos. 1810-1812.

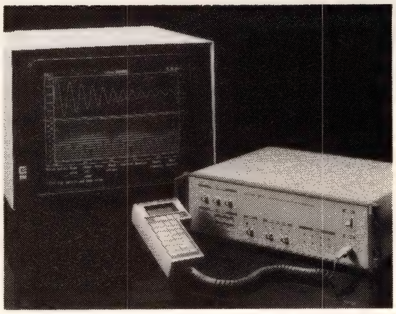
Circle No. 715

RFI Power-Line Filters

The A series of 3-phase RFI filters, designed primarily for 4-wire wye applications, provides filtering in each of the three lines plus the neutral and ground line. You can also use the filters in 3-phase delta systems. Available in 20, 30, 45, and 60A versions, the filters incorporate both common- and differential-mode suppression from 50 kHz to 30 MHz. Their shielded construction makes these filters effective for both balanced and unbalanced 3-phase loads. The units suit line printers, disk-drive controllers, robotics, and numerical-control equipment. They meet IEC-380 specifications and are UL recognized. $118.74 to $203.12 (100).

Corcom Inc, 1600 Winchester Rd, Libertyville, IL 60048. Phone (708) 680-7400. Booth No. 4116.

Circle No. 716



High-Resolution Function Generator

At speeds to 50M samples/sec, the 9112 dual-channel arbitrary-function generator maintains dc accuracy of ±0.3% into a resistive load between 49Ω and 1 MΩ. Amplitude resolution and flatness are 12 bits and 0.1 dB max, respectively. Each channel contains a fast waveform memory, which the 9112 loads with the 16-bit digital representation of digital patterns or analog signals. Both the analog waveform and its digital replica are output synchronously. Independent 12-bit DACs on each channel of the analog-waveform generator provide a S/N ratio of >70 dB. A 32-bit digital-pattern generator provides depths of 64k words (16 bits wide) or 32k words (32 bits wide). $13,900.

LeCroy, Signal Sources Div, 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977. Phone (914) 578-6020. Booth No. 1504.

Circle No. 717

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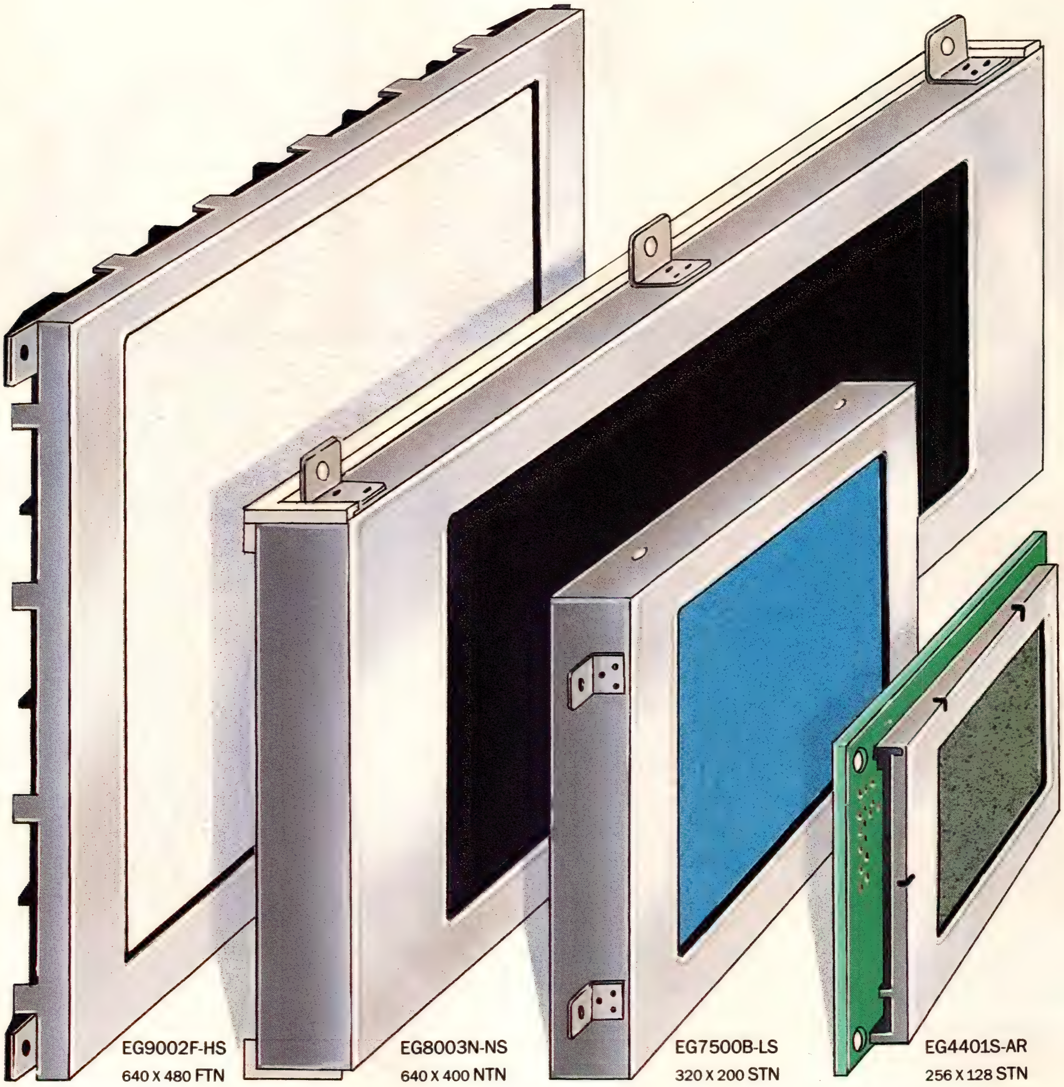

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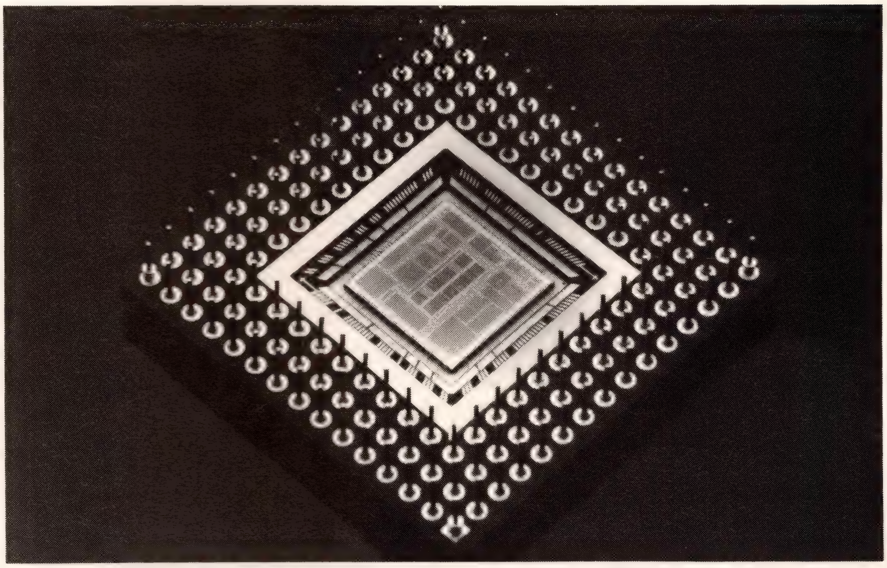
CIRCLE NO. 88

See us at Booth 2115

Image-compression IC handles video rate using industry-standard algorithms

Using the CL550 image-compression IC, you can now add image handling to your system without waiting for I/O bandwidth and memory capacities to increase. The image-compression IC reduces the data rates needed to handle images to within the capability of today's PCs.

The device is a hardware realization of the proposed JPEG/CCITT (Joint Photographic Experts Group) international standard for image compression. The standard's algorithms allow you to compress images in ratios from 8:1 to 200:1; the hardware performs these algorithms as fast as 40M bytes/sec. These parameters are fast enough to let you record or play back video at 30 frames/sec, and dense enough to let you store 3 minutes of compressed video on a 20M-byte hard disk.



Providing both image compression and decompression in the same device, *the CL550 can handle images at rates to 40M bytes/sec. You can vary the compression ratio from 8:1 to 200:1.*

The CL550 features derive from the JPEG algorithms. Because the algorithms are symmetrical operations, for example, the device can compress or decompress images with equal facility. Therefore, you can use just one device to record and play back images. In addition, the algorithms embed compression parameters in the image data. The embedded parameters allow you to reconstruct an image without any guesswork or foreknowledge of how the image was compressed. The JPEG algorithm also allows you to change compression ratios; the device can accommodate changes on a frame-by-frame basis.

Using a combination of discrete cosine-transform and Huffman-coding methods, the device operates on pixels in 8×8-pixel blocks. On-chip registers store the compression coefficients, which are user accessible. The device can handle gray-scale images or color images in the RGB (red, green, blue), CMYK (cyan, magenta, yellow, black), or YUV (luminance/chrominance) color-space representations.

You have two data ports available in the CL550. One port is a pixel bus for transferring image data between the video device and the IC; the other port is a host bus for transferring compressed data and control information between the IC and a host processor. You can configure the host bus to connect with 16- or 32-bit processors.

Because the algorithms operate on an 8×8-pixel block, you'll need to buffer image data off chip if you're dealing with raster-scan images. The device provides all the control signals needed to manage this buffer.

If you use the CL550 to add still-image handling to your next design, you may also be able to retrofit your older designs. You can obtain a software version of the JPEG algorithms called Compression Workshop and use it to read and display compressed images on your older systems. The software is not fast enough to handle video images, however.

The device comes in a 144-pin pin-grid-array package and consumes <1.5W when operating at 27 MHz. Samples will be available in June; full production is scheduled for September. Right now you can obtain a developer's kit containing a sample IC, design notes, and low-level software drivers for $550. The IC itself costs $155 (10,000). The Compression Workshop is available for $500.—***Richard A Quinnell***

C-Cube Microsystems Inc, 399- A W Trimble Rd, San Jose, CA 95131. Phone (408) 944-6300.

Circle No. 732

Single PC/AT STD Bus module implements CPU, memory, graphics, and I/O interface

The CPU-AT replicates all the functions of an IBM PC/AT computer on a single STD Bus module. The module includes an 80C286 µP, a BIOS, as much as 4M bytes of RAM, floppy- and hard-disk controllers, and a choice of flat-panel-compatible graphics controllers. The computer runs the MS-DOS and Unix operating systems, and you can also use it for embedded-system applications.

The CPU-AT's CPU board provides µP clock speeds ranging from 10 to 25 MHz. Under software control, you can switch the processor's clock speed between its maximum and 8 MHz. You can also plug in an 80287 math coprocessor. The board has a 256k-byte ROM or EPROM for a BIOS and other nonvolatile storage needs. For faster execution, the board can transfer the ROM code to shadow RAM.

The board hosts as much as 4M bytes of dynamic RAM (DRAM) with parity. The memory, in excess of 1M byte, functions as extended memory for RAM disks, print spoolers, and Unix or other protected-mode applications. You have the option of purchasing expanded-memory-specification 4.0-compatible memory. The board also includes two 8237 DMA controllers, two 8259 interrupt controllers, and three counter/timers.

I/O features include two RS-232C ports, a parallel port, a battery-backed real-time clock and setup RAM, a speaker driver, and a keyboard port. The 8-bit STD Bus interface meets the IEEE-961 specification and provides 128k bytes of memory addresses and 512 I/O addresses. The STD Bus interface operates at 8 MHz, regardless of CPU speed.

Interfaces to mass storage and graphics devices reside on a second board sandwiched back-to-back with the main board. The 2-board sandwich requires a single slot in an STD Bus card cage, however. The floppy-disk controller runs 3½- and 5¼-in.-disk drives at rates from 360k to 1.4M bytes. The module includes an IDE (integrated device electronics) interface, also referred to as an embedded-AT, hard-disk interface.

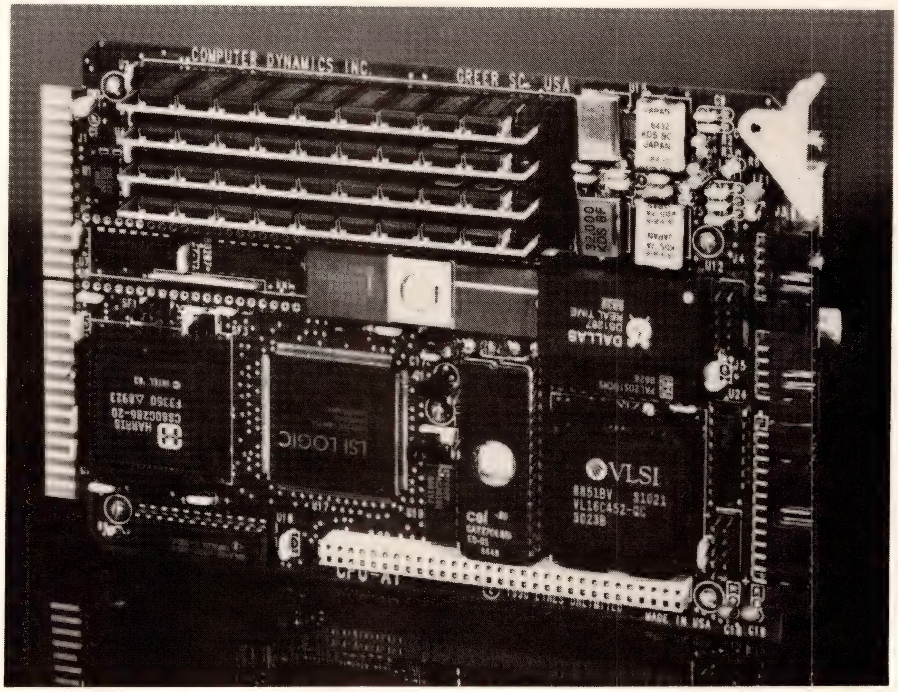
You can choose from IBM CGA, EGA, or VGA graphics; the latter two also include Hercules monochrome graphics support. All the display controllers can drive CRT, liquid-crystal, electroluminescent, and vacuum-fluorescent displays.

In addition to MS-DOS and Unix applications, you can use the CPU-AT for embedded-system applications. The company offers ROM tools and an MS-DOS emulation package to simplify integration in such applications. In rugged environments, the board can boot MS-DOS from CPU ROM rather than from disk. Likewise, the board requires no keyboard or standard display for embedded applications.

The board requires 5V and −12V power supplies, and operates over a 0 to 70°C range. It measures 4.5×6.5×0.85 in. without the mass storage/graphics board and measures 1.4 in. thick with this board. A typically configured board with 10-MHz µP, 512k bytes of RAM, CGA graphics, and disk interface costs $1995 and will be available in May.—***Maury Wright***

Computer Dynamics Sales, 107 S Main St, Greer, SC 29650. Phone (803) 877-8700. FAX (803) 879-2030.

Circle No. 731



The CPU-AT single-slot STD Bus module *provides an IDE disk controller, VGA graphics, memory, and an I/O interface. These features make the CPU-AT suitable for use in MS-DOS, Unix, and embedded applications.*

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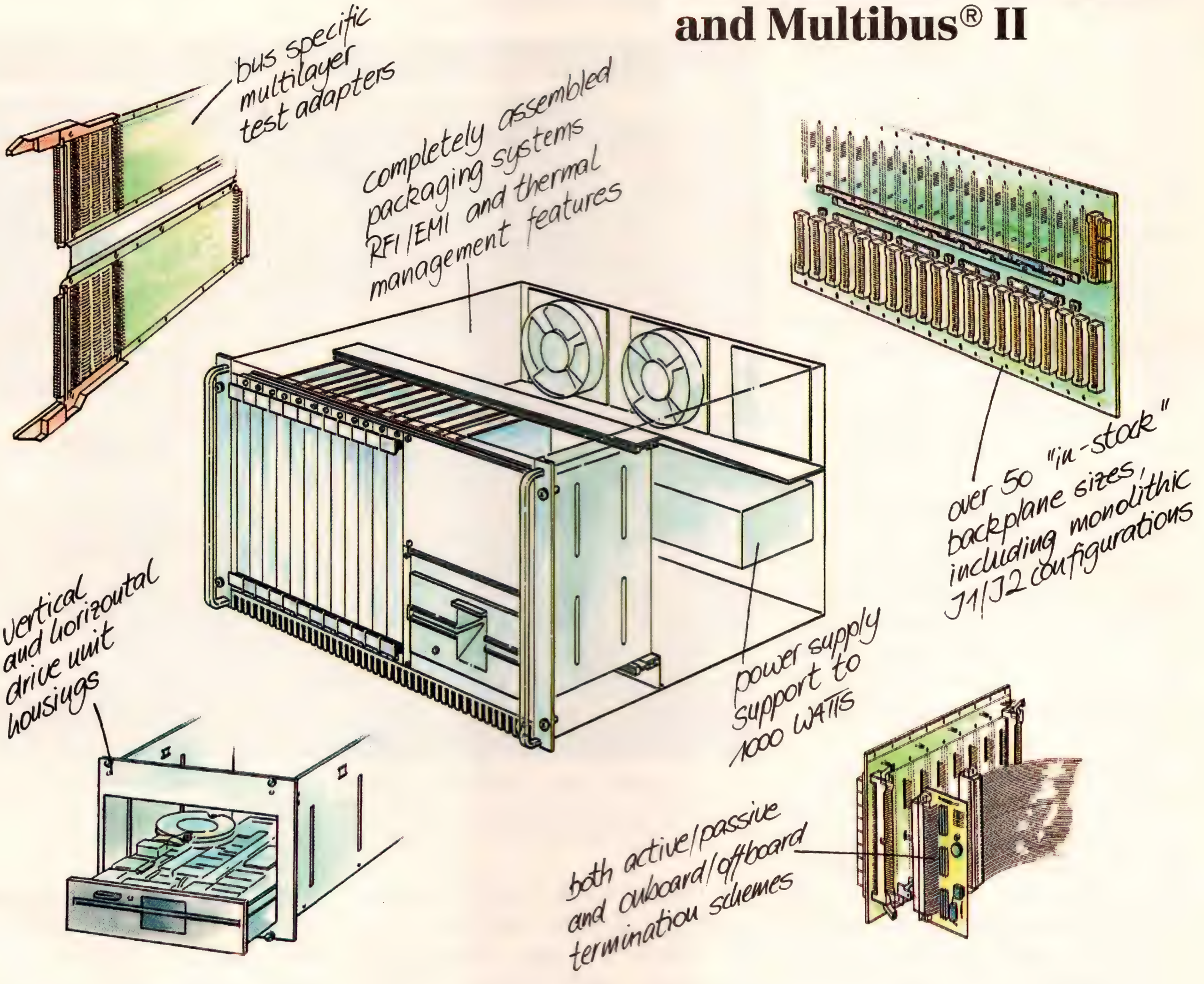
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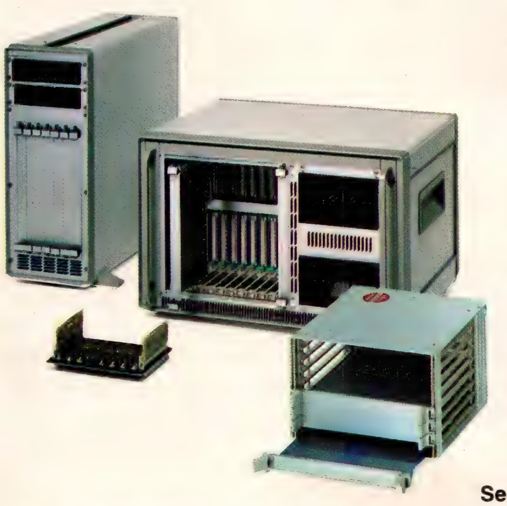

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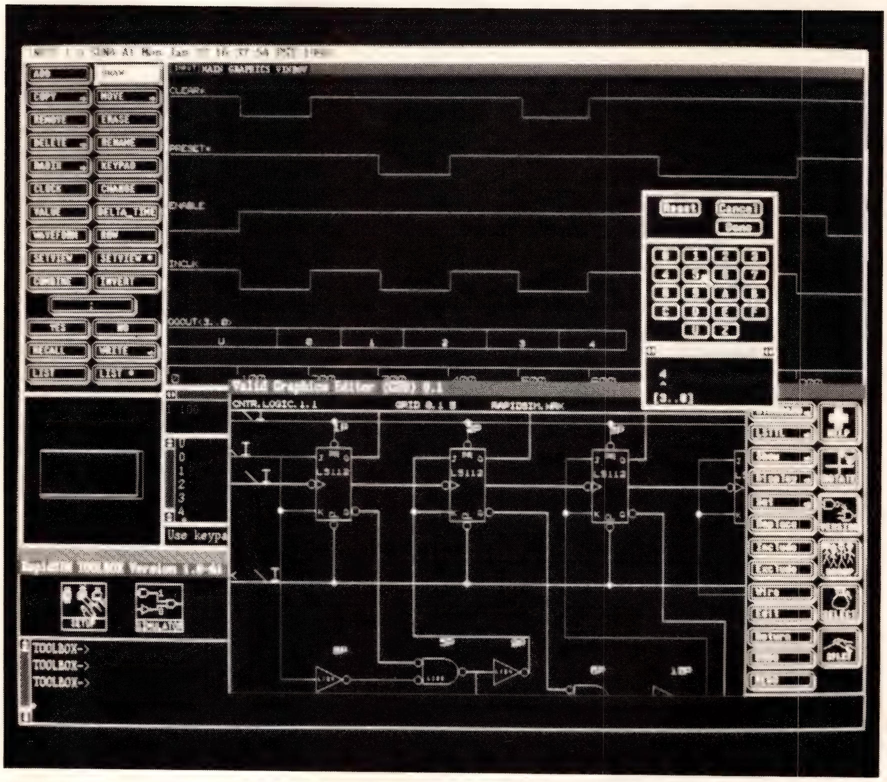
CIRCLE NO. 89

Flexible delay-calculation algorithms improve simulator's accuracy



You can control your digital logic simulation *via conditional breakpoints, loops, and branch instructions. Additionally, RapidSim offers a graphical waveform editor that eliminates the drudgery of typing in stimulus patterns.*

ASIC vendors use different techniques to model the delays of signals propagating along signal lines. With line widths getting smaller and ASICs getting bigger and more dense, the propagation delays often exceed switching delays. RapidSim is a digital simulator that lets you or your ASIC vendor customize the delay-calculation algorithms to accurately represent the timing of signals in your circuit.

Using your own or ASIC-vendor-supplied delay algorithms lets you model and account for the effects of output loading, input slew rates, nonlinear delays, and RC tree analysis. These effects are only approximated by simulators that use intrinsic and loading-delay equations. As layout-dependent effects predominate, these fixed-delay-equation simulators become less accurate.

RapidSim also uses a glitch-propagation algorithm that you can switch between transport mode and inertial mode. In transport mode, the simulator propagates all glitches through gates; in inertial mode, the simulator only propagates glitches longer than a minimum length.

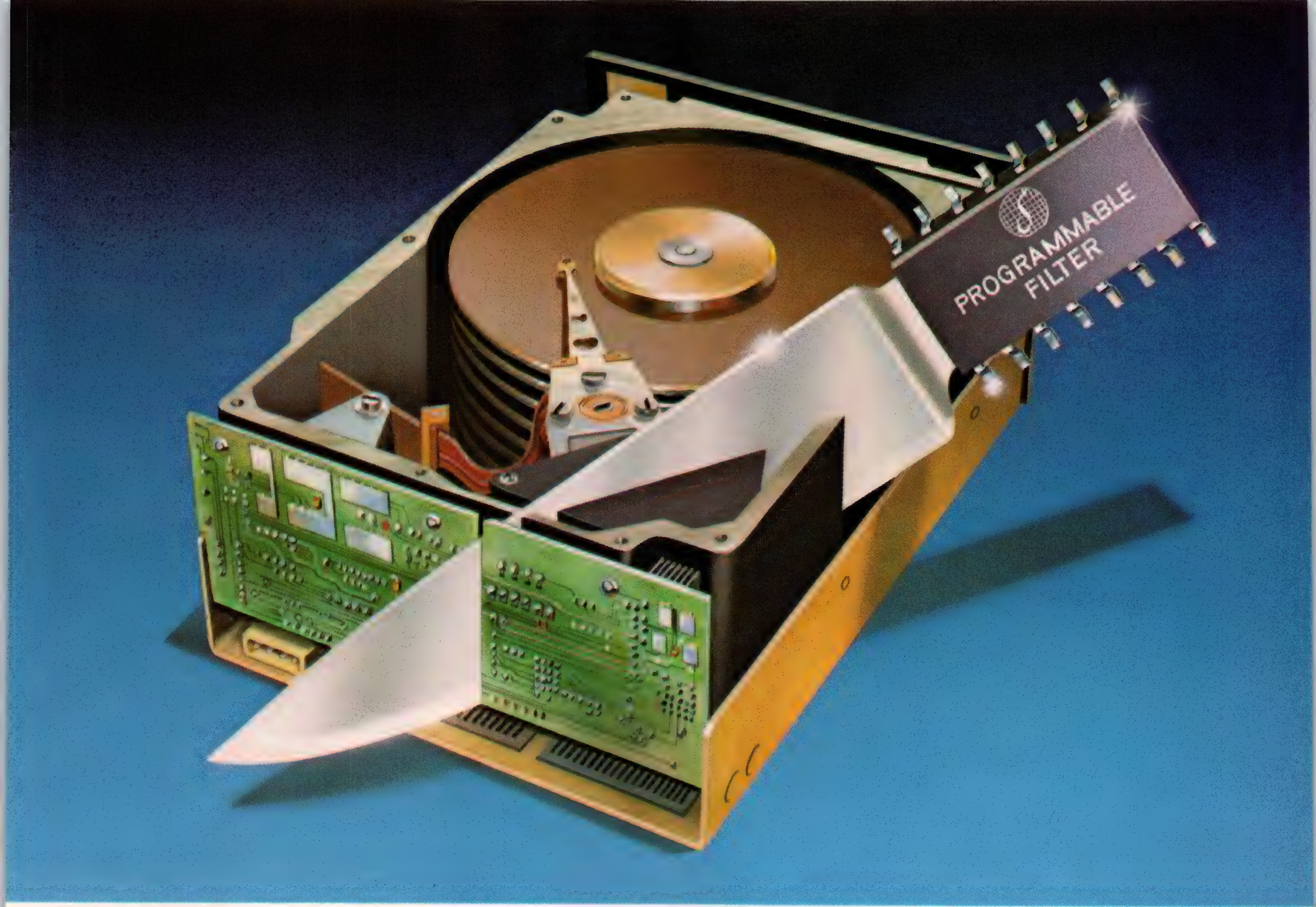
Another consequence of shrinking feature sizes in ICs is an increase in density. As chips become more dense, your simulator needs to accommodate additional gates. RapidSim does this via a gate model that uses 250 to 300 bytes of data. Other simulators use as much as 1500 to 2000 bytes. With RapidSim's smaller gate model, you can load and simulate larger designs; however, there is a cost.

The efficiency of small gate models comes at the expense of a shared database between your simulator and capture tools. These tools can communicate with each other via the vendor's Logic Workbench framework, enabling you to probe the schematic and display important nets. However, the tools don't share data, so you have to manually update your schematic if you make any changes during simulation. Fortunately, the simulator allows incremental compilation, so you only have to recompile the schematic pages that you change.

Useful logic-debugging features, such as conditional breakpoints, supplement the simulator's fast and flexible algorithms. Also, a graphical waveform editor lets you draw rather than type your stimulus patterns.

The simulator offers access to more than 100 ASIC design kits, 4300 standard digital component models, 4500 behavioral models from Logic Automation (Beaverton, OR), and 700 hardware models for Logic Modeling's (San Jose, CA) hardware modeler.

VHDL (VHSIC Hardware Description Language) hasn't been ignored either. In an approach similar to that taken by Silicon Compiler Systems (now Mentor Graphic's Silicon Design Division) (San Jose, CA), RapidSim contains two simulator engines—its own and one for VHDL. You can mix and match models with both engines. More importantly, you don't have to force VHDL, which is a robust and pow-



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A new high-frequency Programmable Filter Chip from Silicon Systems is a significant development for disk drive designers employing constant-density-recording techniques.

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This low-pass filter allows the user to continuously program the channel bandwidth from 5-13 MHz while changing data rate for constant-density recording. Additionally, pulse equalization/pulse slimming levels from 0 to 6dB are programmable. It does it all with no external passive components.

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Circle 52 For Product Info

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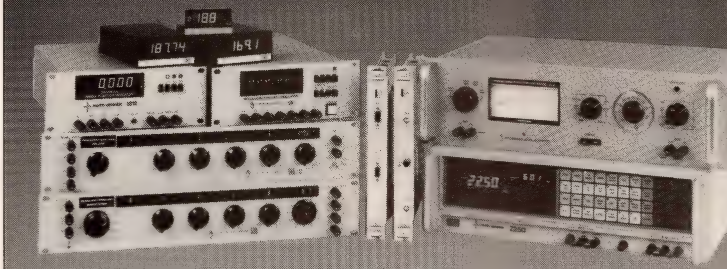

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CIRCLE NO. 90

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CIRCLE NO. 91

erful language, onto an existing, perhaps limiting, HDL.

You can purchase network licenses that allow access to the simulator via the Logic Workbench simulation framework. The software is upwardly compatible with the current ValidSim simulator, and the upgrade is free to current customers under maintenance. New users can purchase a network license for the simulator for $12,000. The simulation framework costs $5000.—***Michael C Markowitz***

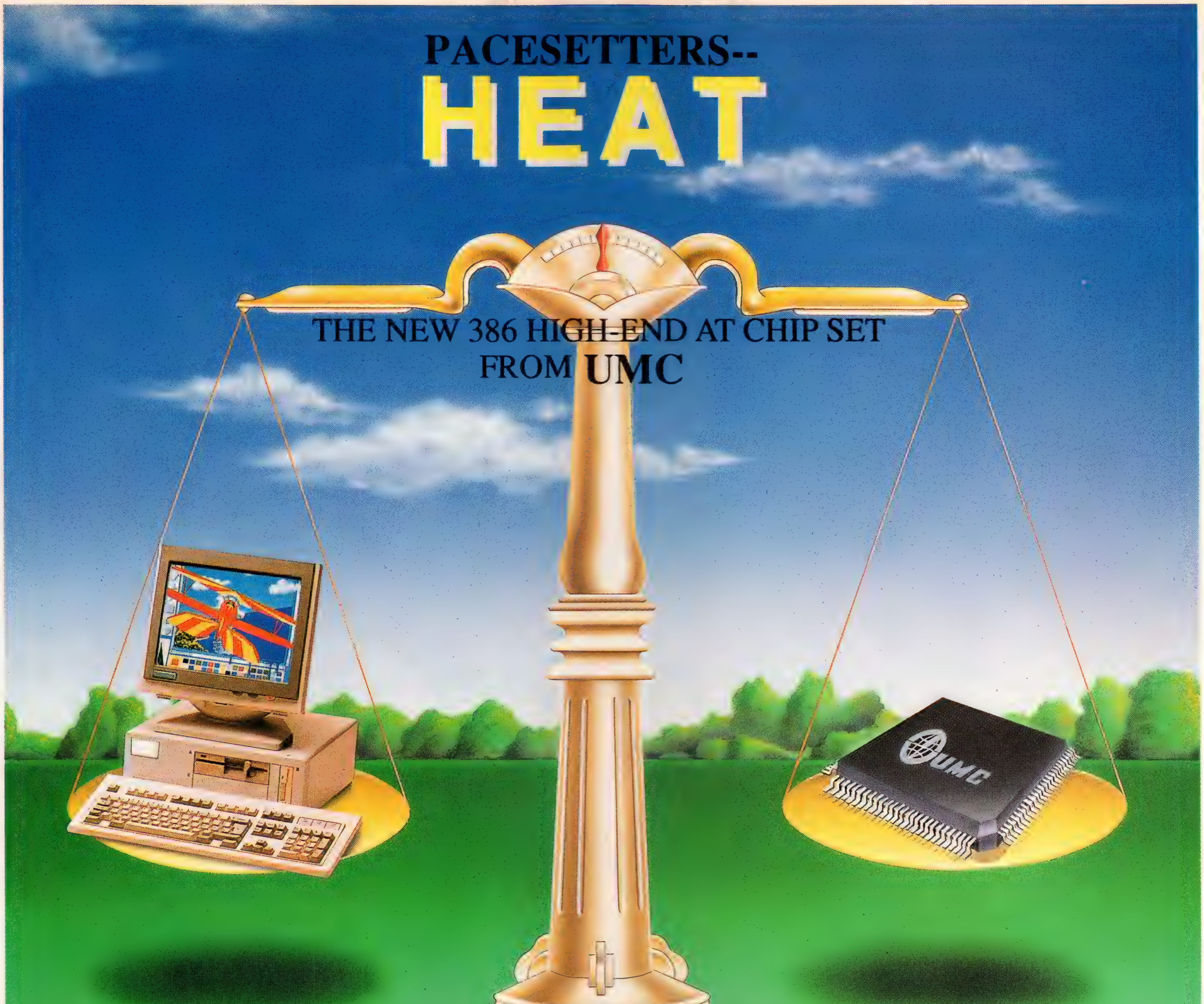
Valid Logic Systems, 2820 Orchard Pkwy, San Jose, CA 95134. Phone (408) 432-9400. FAX (408) 432-9430.

Circle No. 730

WHAT'S COMING IN EDN

EDN Magazine's May 10, 1990, issue will feature a staff-written Special Report on sample-and-hold and track-and-hold amplifiers. Part 3 of the designer's guide to precision dc current sources will discuss the advantages of using two amplifiers. EDN's All-Star PC project will conclude with part 5, which will focus on engineering software. This issue will also feature a staff-written update on handheld digital multimeters. Remember to look for our regular departments, too.

In the May 24, 1990, issue look for a staff-written Special Report on 32-bit embedded controllers and the conclusion of the designer's guide to current sources.



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These stunningly versatile chip set that can be designed with either page mode (20/25MHz, 80386 AT) or cache mode (25MHz, 80386 AT) depending upon customer requirements. Additionally, it can be designed in a baby- sized AT board , requiring only 10 TTL— and without PAL.

UMC is committed to providing its customers with a TOTAL SOLUTION. That's why it sets the pace providing Cache Controller through chip sets.

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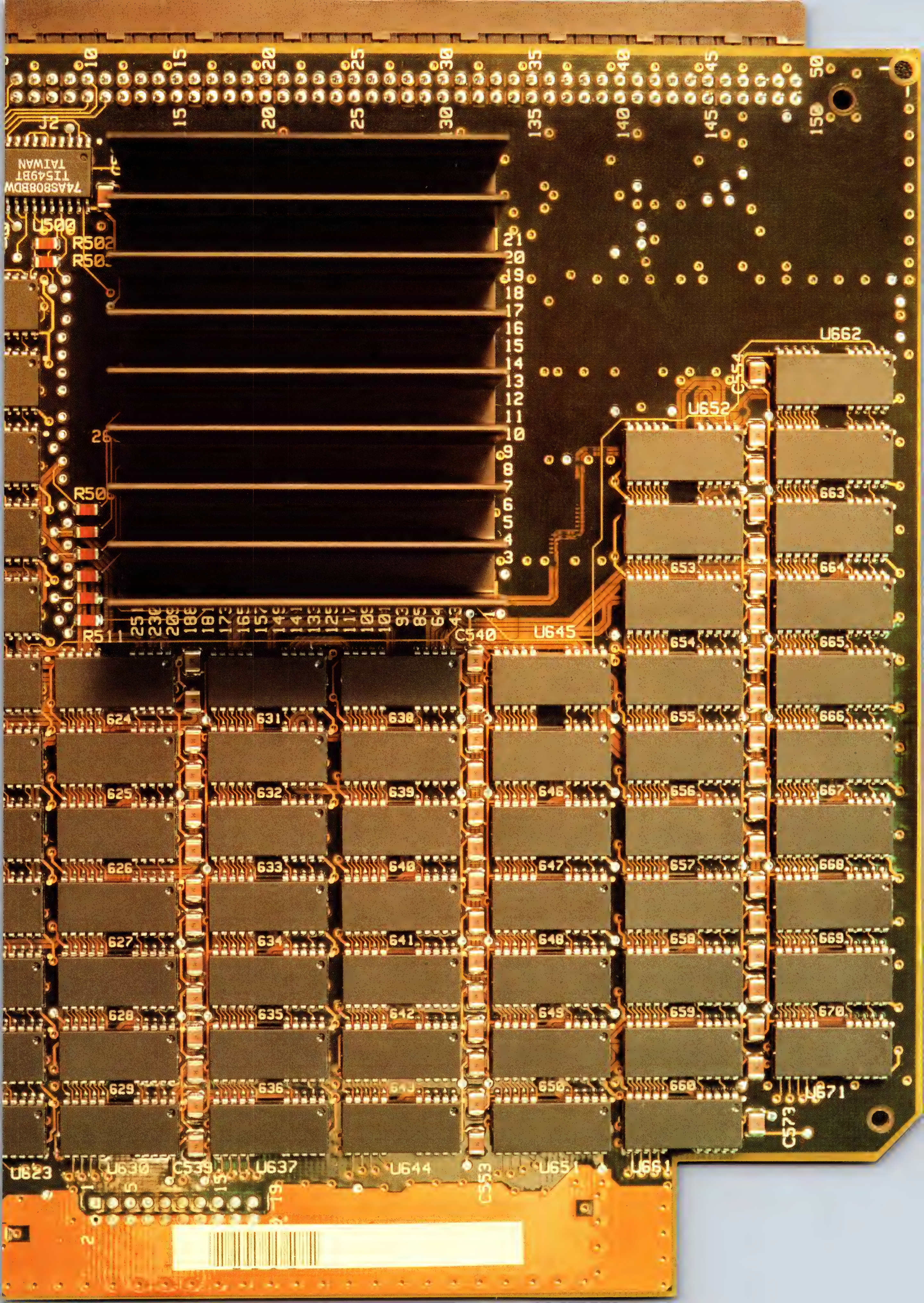
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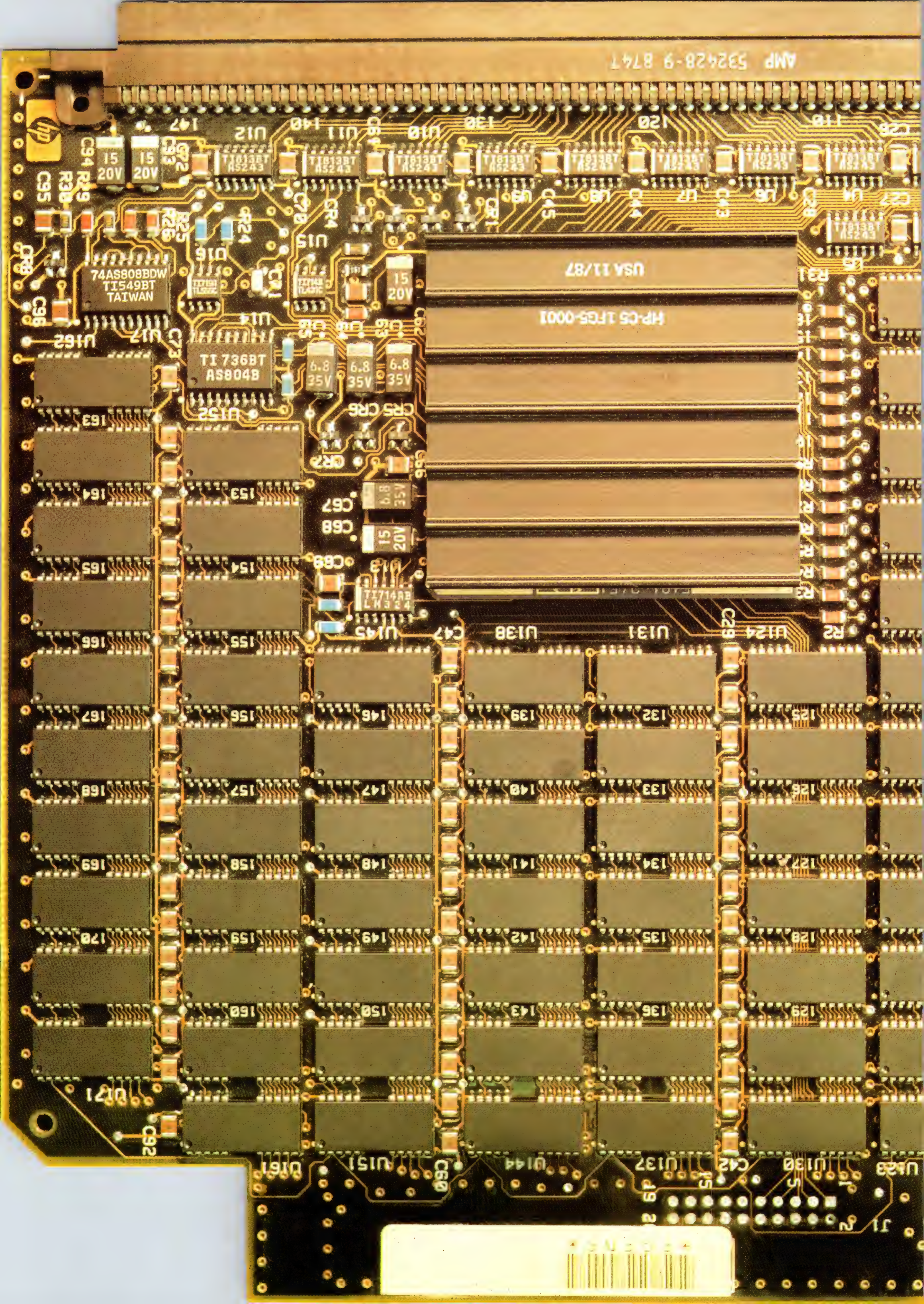
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HP 3065 family for single-sided test
The HP 3065 incorporates a major advance in fixturing called HP Simplate technology.

For a start, we've developed a new, more compressible material to create a smaller vacuum chamber.

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CIRCLE NO. 94

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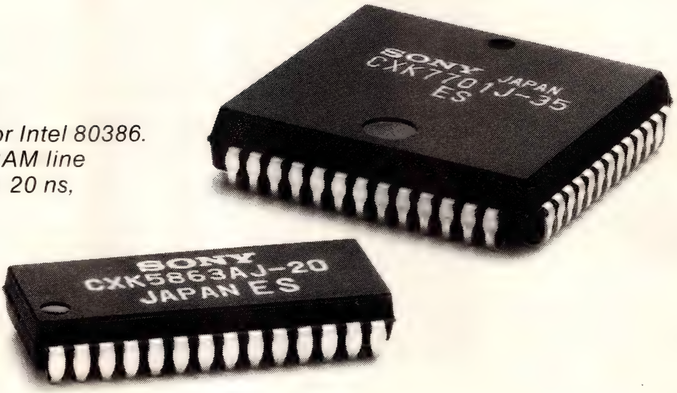


What you see here is a demonstration of Sony's intense commitment to your each and every SRAM need.

A commitment made even more impressive by the fact Sony's only been engineering and producing SRAMs for just over five years.

And when you consider we're pouring all our resources into SRAM technology—including a new production facility in Nagasaki, Japan—this demonstration merely hints at the Sony SRAM technology yet to come.

Ultra-high speed cache.

Via a unique 0.8-micron process, Sony covers your fast processor cache-memory needs two distinct ways.

First, there's our Model CXK7701J, designed specifically for the Intel 80386.

This application-specific memory (ASM) combines address latch, memory and transceiver within one IC. Ready for user configuration as either an 8k x 16-bit memory or as two 4k x 16-bit memories.

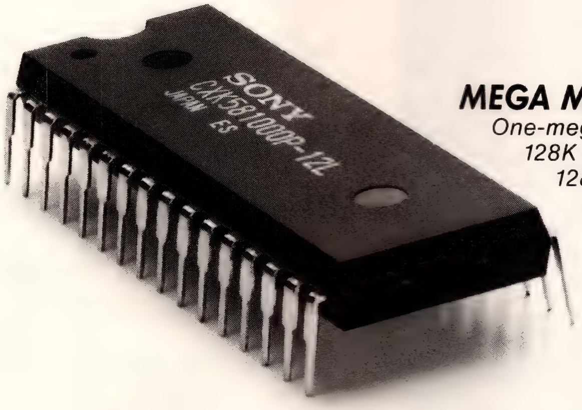
ULTRA-HIGH SPEED CACHE SRAMS			
MODEL	CONFIG.	SPEED (ns)	PACKAGE
CXK7701J*	8K x 16	30/35/45/55	PLCC
CXK5863AP	8K x 8	20/25/35	DIP 300 mil
CXK5863AJ	8K x 8	20/25/35	SOJ 300 mil
CXK5466P	16K x 4	15/20	DIP 300 mil
CXK5466J	16K x 4	15/20	SOJ 300 mil
CXK5467P**	16K x 4	15/20	DIP 300 mil
CXK5467J**	16K x 4	15/20	SOJ 300 mil

*For Intel 80386. **O/E

Second, consider our new ultra-high speed SRAM capabilities.

As you scan the chart above, keep in mind even higher speeds will be available soon.

S ITS SRAM
THE EXTREMES.



MEGA MEMORY.
One-meg SRAM line includes
128K x 8 @ 100/120/150 ns,
128K x 8 @ 70/85 ns,
128K x 8 @ 35/45/55 ns.

Ultra-high density.

Sony solves your board-space problems with three new 1-Mbit SRAMs.

Each is based on our 0.8-micron CMOS technology. Configured as 128K x 8 bits. And available in 32-pin DIP and surface-mount plastic packages.

And not only do Sony 1-Mbit SRAMs maximize board space, but process speeds as well.

HIGH-DENSITY SRAMS

MODEL	CONFIG.	SPEED (ns)	PACKAGE
CXK581000P	128K x 8	100/120/150	DIP 600 mil
CXK581000M	128K x 8	100/120/150	SOP 525 mil
CXK581001P	128K x 8	70/85	DIP 600 mil
CXK581001M	128K x 8	70/85	SOP 525 mil
CXK581020SP	128K x 8	35/45/55	DIP 400 mil
CXK581020J	128K x 8	35/45/55	SOJ 400 mil

Nowhere else will you find a greater choice: 100/120/150-ns, 70/85-ns and 35/45/55-ns speed figures.

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EDN SPECIAL REPORT

Plug-in DSP boards

With the aid of these lightning-fast DSP math crunchers, host computers can compute complex DSP algorithms that execute in faster than 30M flops.

John Gallant, *Associate Editor*

Plug-in digital-signal-processing (DSP) boards are the mathematicians that host computers rely on to swiftly compute complex algorithms. These special-purpose coprocessors contain one or more resident DSP ICs, which are optimized to compute algorithms that occur when digital signals require spectral analysis or parameter enhancements. Host computers usually don't have DSP ICs resident on the mother board, so the plug-in DSP board is playing an increasingly important role in sophisticated data analysis. Diverse, specialized applications for these boards include pattern recognition, data compression, medical imaging, audio-signal analysis and synthesis, spread-spectrum communications for satellites, and radar-pulse compression.

In boards from various vendors that use the same DSP IC, the main differences are the chip configuration and interface ports—in other words, in how each board transfers data to and from the chip. To eliminate bottlenecks on the host's bus, these boards contain plenty of RAM. The RAM supplies the DSP IC with onboard access to enough data to complete most or all of an algorithm's computation without host intervention. Either the host downloads data arrays to the board before execution, or the board inputs data from an external source through onboard serial or parallel I/O ports. The board reports only the results of the computation to the host.

DSP plug-in boards are available for popular computer buses such as the ISA bus, VMEbus, Nubus, and Multibus. Boards for the ISA bus are the most plentiful, followed by boards for the VMEbus.

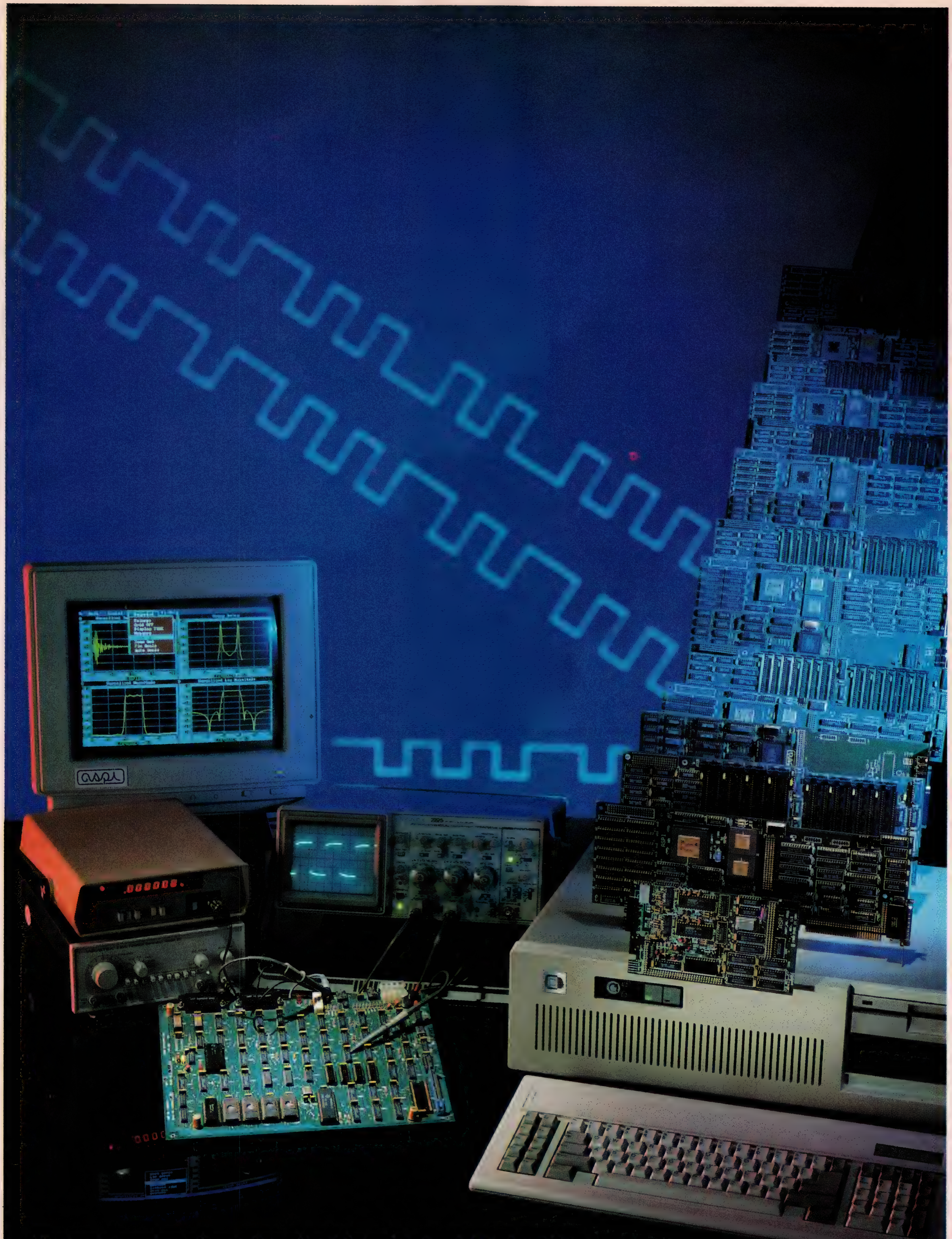
The DSP IC is the computational muscle of the plug-in DSP board. DSP ICs have pipelined Harvard architectures and instruction sets that are optimized for DSP **(Ref 1)**. In addition to large register sets, the chips have internal RAM and ROM that minimize the time it takes to transfer data to the internal registers.

The boards contain one or more DSP ICs fabricated by any of these semiconductor manufacturers: Analog Devices, AT&T, Motorola, Texas Instruments (TI), or Zoran. These five vendors are the only companies that provide a variety of software-development tools that third-party board vendors can easily port to a Sun Workstation, IBM PC-compatible, or Apple Macintosh host computer.

Essential software-development tools for DSP boards include assemblers for translating DSP assembly-language source files into DSP machine-code object files and linkers that combine multiple object files into one executable object file. All of the IC vendors except Zoran offer C compilers for generating DSP assembly-language source code.

In addition, the five IC vendors provide simulators that run on the host. These software tools simulate the DSP IC's operation and can execute the programs more slowly than real time. The simulators operate on the executable object file to display the contents of registers, program and data memories, and internal buses during program execution. For debugging DSP programs, the simulators feature single-step operation, program breakpoints, and register modification.

For algorithms that require greater speed, certain boards contain multiple DSP ICs and high-speed parallel buses. The buses transfer data between multiple DSP boards by bypassing the host bus. These configu-



The computation of complex algorithms for specialized applications is no problem for high-powered DSP boards. (Photo courtesy Atlanta Signal Processors Inc; photography by Kern Thompson)

Vendors of DSP ICs provide a variety of software-development tools that third-party board vendors can easily port to a host.

rations let you run DSP programs in parallel or in a pipeline. The high-speed buses also can connect to off-the-shelf or custom data-acquisition boards. In addition, some boards contain analog I/O channels with A/D and D/A converters.

Boards rely on chip's DMA features

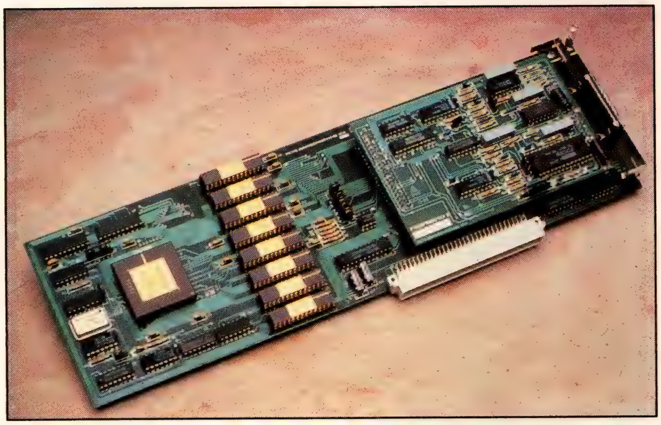
Many vendors of plug-in DSP boards exploit the architecture and speed of AT&T's WE DSP32C DSP chip. A 50-MHz WE DSP32C chip can multiply and accumulate two 32-bit floating-point numbers in 80 nsec, which gives the chip a rating of 25M flops. Plug-in DSP boards that employ just one of these ICs boast the same rating. The chip also has a DMA controller that can transfer data to a 16-bit parallel I/O port and a serial I/O port without interrupting computations.

A typical architecture for the DSP32C is the ZPB34 board from Burr-Brown. The board connects the chip's parallel I/O port to a 16-bit ISA bus through a bus-interface chip. The DSP chip's serial I/O port can read or write data back and forth between two 10M-bps serial I/O ports on the board. Four versions feature onboard RAM ranging from 64k to 576k bytes. The RAM connects to the chip's memory-expansion port. The board maps onto 16 ports of the ISA bus's I/O address space.

The boards from Communications Automation & Control that have DSP32 or DSP32C chips also use the method of connecting the chip's parallel I/O port to the ISA bus for data transfers. Various models feature A/D and D/A converters as well as codecs. The boards also map onto the PC's I/O space and can communicate with a dedicated host at 3.5M bytes/sec using programmed I/O data transfers. As long as the program-execution time is longer than the data-transfer time, the host won't interrupt the DSP program.

Spectral Innovations' DSP256KC connects the DSP32C's parallel I/O port to the Macintosh Nubus. The board contains 256k bytes of local RAM for DSP use and ROM that stores the board's configuration. A multiplexer switches the chip's serial I/O port to either two 16M-bps serial I/O ports or to a connector that attaches to data-acquisition daughter cards. The daughter cards contain multichannel, analog I/O ports for A/D and D/A converters.

Instead of using the parallel I/O port as a bus interface, the Racer Series of VMEbus boards from Transformation Systems has an on-chip, 32-bit memory-expansion port that shares a VMEbus interface with 32k×32 bits of onboard static RAM (SRAM) and 2M×32 bits of onboard dynamic RAM (DRAM). The board uses the chip's parallel I/O port as a private communication bus for multiple board configurations. In addition, the board has as much as 2k×32 bits of FIFO memory between its shared-memory bus and a 40M-byte/sec 32-bit data link, which can pass data between adjacent boards in a pipeline.



The MacDSP employs a 50-MHz DSP32C and a Nubus configuration in ROM. *The Macintosh computer board from Spectral Innovations provides a connector for optional data-acquisition cards.*

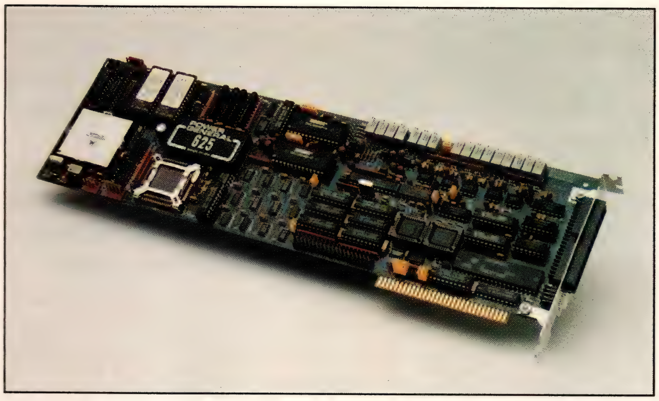
The VE-32C-01V board from Valley Enterprises contains four DSP32C chips. The parallel I/O ports of each IC connect to a 16-bit bus that communicates with the VMEbus as an A16:D16 slave. Each chip can generate a VMEbus interrupt on any one of the seven levels. Each DSP IC has as much as 32k×32 bits of dedicated expansion SRAM. Each of the memory-expansion ports connects to a 16-bit digital matrix switch that connects to either the P2 connector or the front panel. The switch accepts data through a 1k×16-bit or 2k×16-bit FIFO buffer and can handle 10M words/sec. In addition, the DSP ICs can provide daisy-chained communications via their serial I/O ports. A VMEbus system with 16 boards can achieve 1.6G flops.

Integer chips are alive and well

Like AT&T's DSP32C, Motorola's 20-MHz DSP-56001 is a DSP IC that serves as the heart of numerous plug-in boards. The chip performs integer arithmetic and has a 100-nsec instruction cycle and a 24-bit-wide data bus. In addition, the chip (and consequently a board that contains one of these chips) has a rating of 10.25 MIPS and calculates a 1024-point FFT in 3.4 msec. It also has a dedicated host-interface port that transfers data on and off the chip without interrupting program execution. Typical board configurations connect the host-interface port to the host-computer bus **(Fig 2)**.

Microstar Laboratories' DAP2400 communicates with an 8-bit ISA bus through an onboard 256×8-bit FIFO buffer memory. The board has a 16-bit data bus that connects to the FIFO memory, the DSP56001's host-interface port, as much as 32k×24 bits of RAM, 64k×16 bits of firmware in ROM, and to a 16-MHz 80C186 µP, which runs the company's DAPL OS. The board's 16-channel analog-input port has a 12-bit A/D converter. The board also has two 12-bit D/A analog-output channels, and a 16-bit digital-input port for data acquisition. A high-speed version features an analog sampling rate of 250,000 samples/sec.

Spectrum Signal Processing Inc (SSPI) offers ISA bus and VMEbus boards that feature the DSP56001. The company is the most prolific of the DSP board vendors; it offers more than 25 boards, several of which are listed in **Table 1**. The company is a North American affiliate of Loughborough Sound Images in Leicestershire, England. In addition to the DSP56001-based boards, the company supplies boards for all of TI's DSP chips and for Analog Devices' ADSP 2100 and 2101 DSP ICs.



***Featuring an analog sampling rate of 235,000 samples/sec,** the DAP2400 ISA bus board from Microstar Laboratories contains a 20-MHz DSP56001 DSP IC, a 16-channel A/D converter, dual D/A converters, and an 80186 µP for scheduling tasks on the DSP chip.*

The DSP56001 system board from SSPI maps the chip's host-interface port onto one of the ISA bus's 16 I/O ports. The chip's memory-expansion port can access 16k×24 bits of program RAM and 32k×24 bits of data RAM. The DSP board has two analog I/O channels with 16-bit A/D and D/A converters that can sample as fast as 153 kHz. It also has an input port that connects to an Intel 29C13 codec, and it provides connectors for the DSP IC's 2.5M-bps, asynchronous, serial-communication interface (SCI) and its 5M-bps, synchronous serial interface (SSI).

All of SSPI's boards feature a 16-bit bidirectional expansion bus called DSP-Link **(Fig 1)**. This bus exchanges data with a slave board at 5M, 10M, or 12.5M words/sec. The interface lets you add modular I/O capability, DSP-node pipelines, and memory expansion to the board. The company supplies standard slave boards or assists you in developing custom slaves.

Ariel offers DSP56001 boards for the ISA bus and for Hewlett-Packard's 9000 Series 300 workstations. The workstation model, called the DSP-300, has a 24-bit onboard bus that connects to as much as 64k×24 bits of program memory, as much as 64k×24 bits of data memory, and the chip's host-interface port. The shared-memory bus has buffer interfaces to HP's DIO

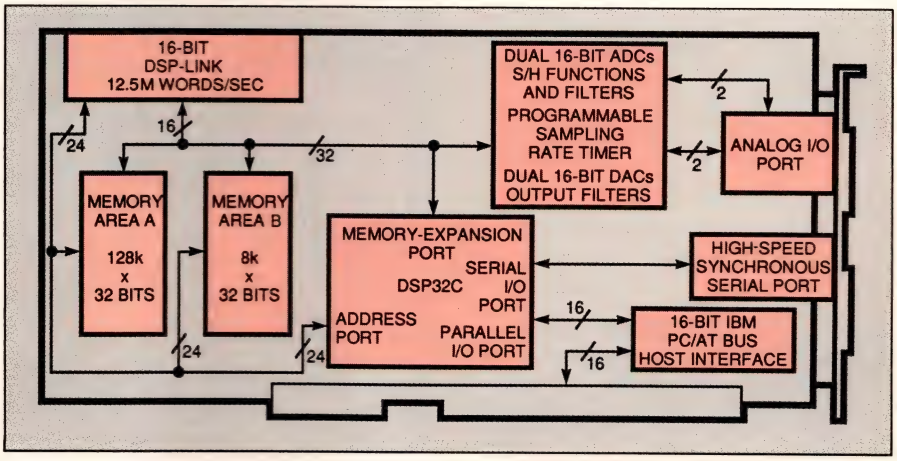


***Fig 1—Most plug-in boards with an AT&T DSP32C chip** transfer data to the host via the chip's DMA-controlled, 16-bit parallel I/O port. Spectrum Signal Processing's DSP32C system board provides the chip with as much as 13k×32 bits of onboard memory.*

The DSP IC is the computational muscle of the DSP board.

bus and an external I/O port. Transferring data over the dedicated external I/O port reduces bottlenecks on HP's DIO bus. HP-UX drivers with source code are optional.

As of this writing, Ariel is planning to demonstrate its MM-96 ISA bus board, which contains prototypes of two DSP96002 floating-point ICs, at the ICASSP show in Albuquerque, NM, in April. The board will feature as much as 4M bytes of DRAM, Data Translation's DT-Connect bus for video I/O data, and the company's DSPnet port for audio I/O data. DSPnet, the company's 32- or 64-bit parallel bus, will exchange data between DSP and data-acquisition boards at 20M bytes/sec and 64M bytes/sec, respectively. The board will sell for $2995.

The founding father of DSP ICs

Texas Instruments is the granddaddy of DSP IC vendors; the company was the first manufacturer of DSP ICs and also is the most prolific. Therefore, it isn't surprising that an abundance of boards contain ICs from TI's TMS320 family. The TMS320C25 is the top of the line from the company's second generation of integer DSP chips. The 40-MHz chip delivers 12.5 MIPS and can multiply and accumulate in a single 100-nsec instruction cycle. A 50-MHz version can perform this operation in 80 nsec. The chip interfaces with external devices through a 16-bit bidirectional data bus and a codec-compatible serial port.

Several ISA bus boards from Atlanta Signal Processors Inc (ASPI) employ ICs from the TMS320 family. The Chimera/50 has a 16-bit shared-memory bus that connects to an ISA bus interface chip, the bidirectional data port on a 50-MHz TMS320C25 chip, and as much as 64k×16 bits of shared memory. This configuration lets the host communicate with the shared-memory bus through DMA or direct-register transfers.

The chip's serial I/O ports connect to A/D and D/A converters that sample at 19,200 samples/sec. Alternatively, the serial ports can connect to the company's wire-wrapped daughter boards, which plug directly into the mother board. The wire-wrapped boards allow you to develop prototypes of data-acquisition modules.

The ISA bus and the TMS320C25's data port can access the 8k-byte, dual-port program RAM resident on Dalanco Spry's Model 25 board. The chip's data port also communicates with the host through DMA and two 16-bit direct registers. In addition, the data port transfers data to an external parallel I/O port and 12-bit A/D and D/A converters that sample at 110 kHz.

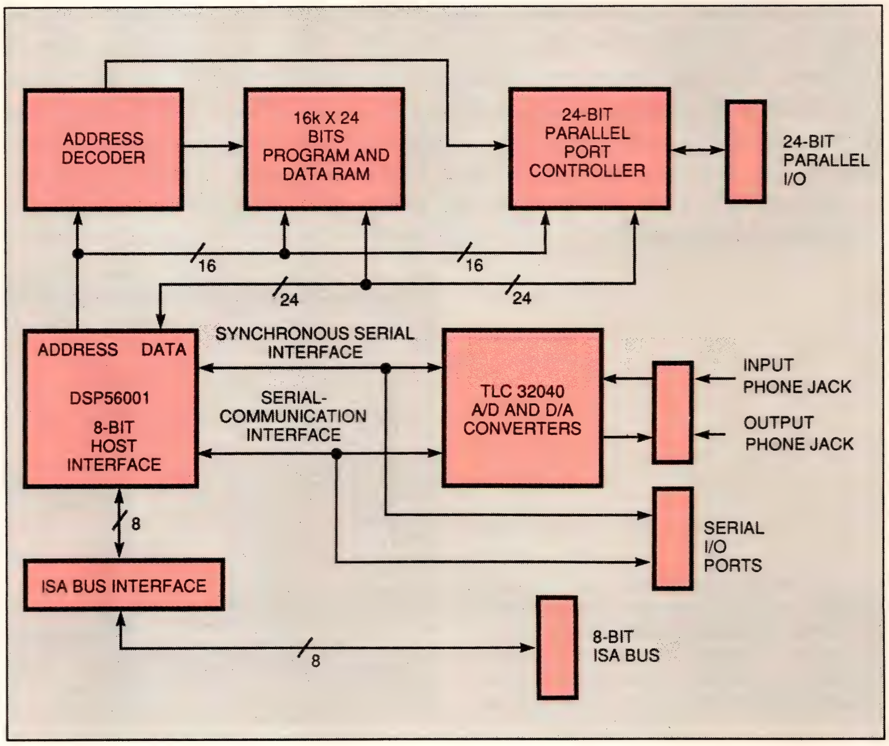


Fig 2—Motorola's DSP56001 chip has an 8-bit port for host communications. *Ariel's PC-56 contains 16k×24 bits of expanded memory, a 24-bit parallel I/O port, phone jacks for the A/D and D/A analog channels, and two serial I/O ports.*

The board also provides access to the chip's serial port.

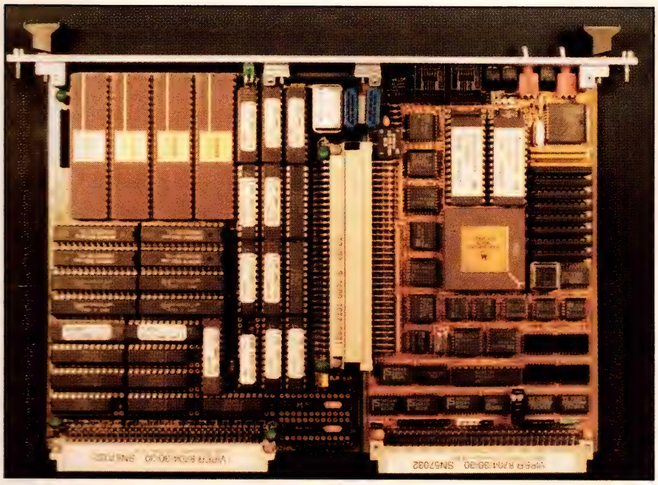
The 33-MHz TMS320C30, a third-generation member of the TMS320 family, performs both floating-point and integer calculations. It can multiply and accumulate in one 60-nsec instruction cycle, which gives it a rating of 33M flops. In addition to its 32-bit primary data port, the chip has a 32-bit memory-expansion port and two independent serial I/O ports, all of which can transfer data to an on-chip peripheral bus via the chip's internal DMA controller.

All of the plug-in DSP boards that use the TMS320C30 for the ISA bus run on Spectron Microsystem's SPOX operating system. This real-time OS, which has functions that a C program can access, comprises a DSP math package for manipulating vectors, matrices, and filters; memory-management software that stores data in different segments of system memory; I/O software that uses peripheral devices to transfer data; and a real-time kernel that schedules and synchronizes multiple tasks.

Sonitech's Spirit-30 board transfers data from the ISA bus to the primary data port on the TMS320C30 via a shared-memory bus, which features 32k × 32 bits of 25-nsec SRAM. An onboard expansion connector connects the shared-memory bus to as much as 16M bytes of additional memory. An optional daughter card can communicate with the chip's expansion-memory port to increase the chip's memory by 512k bytes. The chip's two serial ports transfer data on and off the board using DMA. In addition, the board has a 16- or 32-bit parallel I/O port. You can also get a plug-in digital I/O card that transfers data to and from a Sun Workstation, Apple Macintosh, or IBM PS/2 host computer at 2M- to 4M-byte transfer rates.

ASPI's Banshee board lets the ISA bus communicate with the TMS320C30's primary port through data-exchange registers. The primary port also communicates with as much as 128k × 32 bits of onboard shared memory and an expansion-memory connector, which can provide an additional 16M bytes via an optional daughter card. The chip's expansion port communicates with the ISA bus through DMA registers or through 8k bytes of dual-port memory. Peripheral devices and an I/O expansion connector for developing prototypes of data-acquisition boards can access the chip's two serial I/O ports.

Pacific Cyber/Metrix has three TMS320C30 chips on its DSP-32 VMEbus board **(Fig 3)**. The chips' primary ports are interconnected through 512 × 32-bit FIFO buffers, and you can arrange them in a pipeline with other VMEbus boards using three 33M-byte/sec, 32-bit parallel I/O ports. Each DSP chip's expansion port has 128k × 32 bits of private memory and connects to the VMEbus and the VSBbus through a local bus interface. The board has a block-mode DMA controller that can transfer data over the VMEbus at 80M bytes/sec. For interprocessor communications, the DSP chips are also interconnected through 8M-bps serial ports.



***The Viper 8704 contains four Zoran 34161 chips and a 68030 µP** that handles the arbitration of multiple DSP tasks. The VMEbus board from Impact Technologies uses a high-level instruction set.*

The DSP-32 board employs a 68030 µP and 68882 floating-point unit that assign tasks to the DSP chips and handle master and slave communications with the host. The µP runs on the company's data-flow operating system, FLOS. Using graphics tools, you can draw flow charts for complex, multi-DSP operations. The development tools build a set of data tables from the flow charts, and FLOS automatically distributes these tables to the DSP chips during program execution.

Zoran's 20-MHz ZR34161 is another DSP IC that has found its way onto third-party DSP boards. The IC, called the Vector Signal Processor (VSP), features an instruction-cycle time of 100 nsec. The chip's architecture is optimized for FFT calculations using integer or block-floating-point arithmetic. It uses a high-level instruction set that includes a single instruction for computing an FFT. A sequence of statements (Load Data, Do FFT, Store Results) can compute a 128-point complex FFT on data stored in external memory in 237.4 µsec.

The Viper 8704 from Impact Technologies has four

High-speed parallel buses let you run DSP programs in parallel or in a pipeline.

VSPs that communicate with a common 16-bit bus, which interfaces with the VMEbus as a master or slave. A 25-MHz 68030 μP has shared access to 1M byte of DRAM and as much as 4M bytes of ROM. The μP handles VMEbus communication and provides round-robin or prioritized arbitration. By using a dynamic-arbitration architecture, the μP also provides local arbitration for the four VSPs on the board's bus. The architecture permits bus requests from any of the VSPs, the 68030, or two external sources attached to the bus via the VMEbus P2 connector. The μP also communicates with two RS-232C ports.

Table 1 lists three benchmarks that plug-in DSP board vendors use as a qualitative measure to evaluate the computational performance of their boards: 1024-point complex FFT, matrix multiplication, and FIR filter. For the most part, however, these benchmarks reflect the capabilities of the particular DSP chip, along with a bit of added time for transferring data on and off the chip. The benchmark figures assume that the data arrays reside in the onboard memory, so the figures don't include the time it takes to transfer data on and off the board. Vendors use different algorithms and data-transfer methods for the DSP chips, so benchmark figures give you only a general idea of computational speed for specific DSP algorithms (**Ref 2**).

The performance figures of some DSP boards exceed those of most accelerator boards. For example, DSP boards that have a 50-MHz DSP32C provide 25M flops and 12.5 MIPS, and DSP boards with a 33-MHz TMS320C30 provide 33M flops and 16.7 MIPS. In contrast, an 80386 accelerator board with a coprocessor

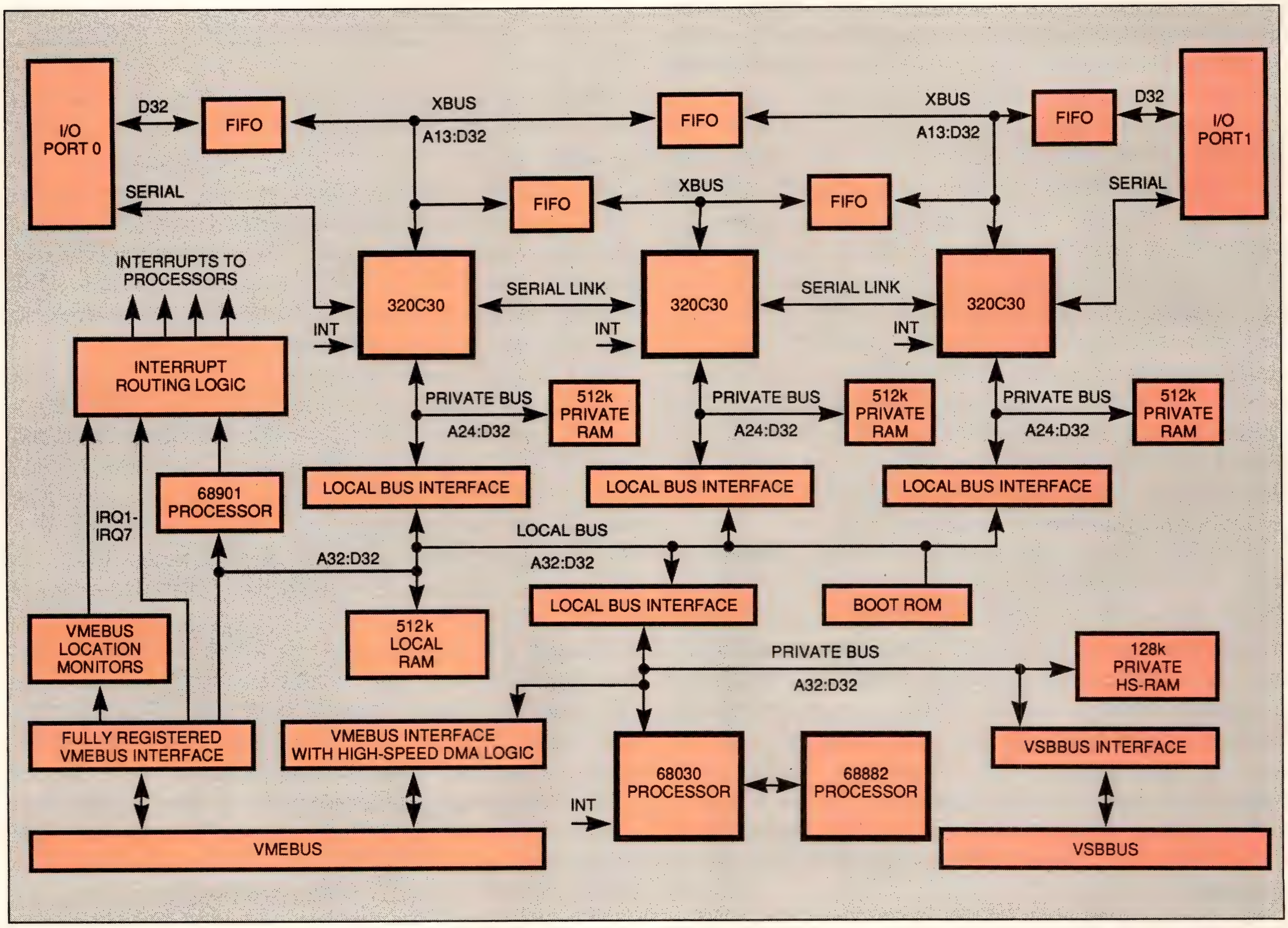


*Fig 3—**For pipelining DSP tasks on multiple boards,** high-end plug-in DSP boards contain multiple DSP chips and high-speed parallel buses. The DSP-2 from Pacific Cyber/Metrix has three interconnected TMS320C30 DSP ICs and a 68030 μP that assigns tasks to the chips.*

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A dedicated host-interface port transfers data to and from the DSP IC without interrupting program execution.

delivers less than 5 MIPS and 5M flops. Therefore, it isn't surprising that plug-in DSP boards are also used for general-purpose mathematical operations such as repeated floating-point multiplication and addition.

The increasing need for easy-to-use software-development tools that shorten the time to market has made your choice of software as important as your hardware considerations. In addition to the offerings of IC vendors, board vendors supply software-development tools for their DSP boards.

For example, Communications Automation & Control supplies a symbolic debugger called the D3EMU

For more information . . .

For more information on the plug-in DSP boards discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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for displaying and modifying memory contents. DSP Research provides a C source-level debugger for their TMS320C30-based Tiger 30 board. Microstar Laboratories' DAPView interactive data-acquisition program includes real-time graphics, and Sonitech's EDSP program debugs DSP applications running on the Spirit-30 board in real time. In addition, some boards operate with popular signal-analysis programs such as DADisp from DSP Development Corp (Cambridge, MA) and Hypersignal-Workstation from Hyperception (Dallas, TX). You can choose from many more software-development tools from other third-party vendors. **EDN**

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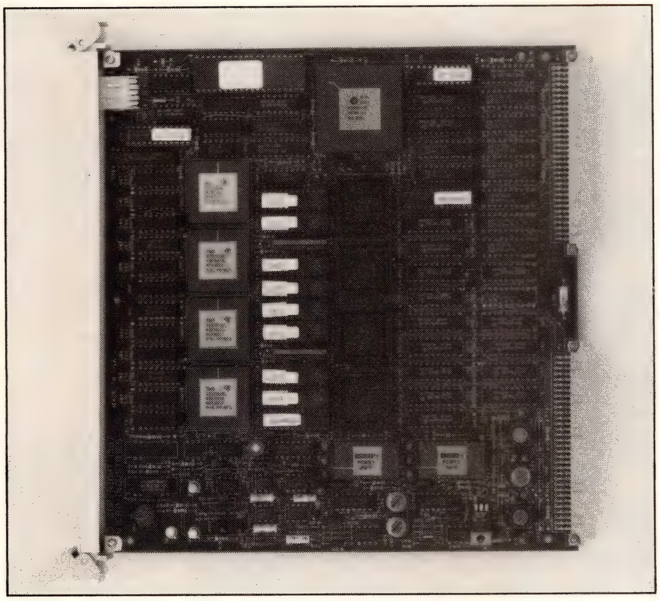

Micro Industries' MIB II 32025 board for Multibus II contains four 40-MHz TMS320C25 DSP ICs. *The four ICs on the board communicate with each other through dual-port RAMs, and they communicate with a high-speed local bus that exchanges data with the host via a message-passing coprocessor.*

References

1. Travis, Bill, "Single-chip DSPs advance in speed and versatility," *EDN*, October 12, 1989, pg 125.

2. Shear, David, "EDN's DSP Benchmarks," *EDN*, September 29, 1988, pg 126.

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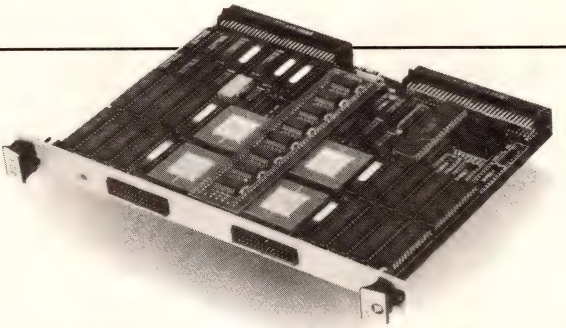

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Table 1—Representative plug-in DSP boards

Company	Model	Bus compatibility	DSP IC	On-chip RAM (bits)	Onboard RAM (bits)	ROM (bits)	I/O ports	Power
Ariel	DSP-C25	8-bit ISA bus	40-MHz TMS320C25	288×16 (data), 256×16 (program or data)	64k×16 max (shared with host)	4k×16 (on DSP IC)	Optional 14-bit analog, 16-bit parallel, serial	5V at 3W
	DSP-56	8-bit ISA bus	20-MHz DSP56001	512×24 (program), 512×24 (data)	64k×24 max (program), 128k×24 max (data)	32×24 (on DSP IC)	12-bit analog, SCSI, serial, 32-bit DSPnet (20M bytes/sec) or 64-bit parallel (40M bytes/sec)	5V at 11W
	DSP-16 Plus	8-bit ISA bus	20-MHz TMS32020 or TMS320C25	288×16 (data), 256×16 (program or data)	64k×16 max (program), 1M×16 max (data)	4k×16 (on TMS320C25 only)	Two 16-bit analog, 16-bit parallel, optional SCSI	5V at 11W
	DSP-300	HP9000 Series 300	20-MHz DSP56001	512×24 (program), 512×24 (data)	64k×24 max (program), 64k×24 max (data)	32×24 (on DSP IC), 2k×8 (on board)	24-bit parallel to DSP bus, asynchronous serial	5V at 3W
	DSP-32C	16-bit ISA bus	50-MHz DSP32C	1.5k×32	16k×32	1k×32 (on DSP IC)	16-bit analog, SCSI, 32-bit DSPnet (20M bytes/sec) or 64-bit parallel (40M bytes/sec)	5V at 11W
	PC-56	8-bit ISA bus	20-MHz DSP56001	512×24 (program), 512×24 (data)	64k×24	32×24 (on DSP IC)	14-bit analog, 24-bit parallel, serial connector	5V at 3W
Atlanta Signal Processors	320/PC-25	Daughter board for 320/PC-15	36-MHz TMS320C25	288×16 (data), 256×16 (program or data)	64k×16 max (program), 64k×16 max (data)	4k×16 (on DSP IC)	8-bit parallel expansion port	12V at 3W
	Chimera/50	16-bit ISA bus	50-MHz TMS320C25	288×16 (data), 256×16 (program or data)	64k×16 max (shared memory with host DMA controller)	4k×16 (on DSP IC)	Connector for A/D and D/A 16-bit daughter board or custom board	5V at 10W
	Banshee	16-bit ISA bus	33-MHz TMS320C30	2k×32 (program or data), 64×32 (program cache)	8k×8 dual port to ISA bus, 512k×8 max (shared memory)	4k×32 (on DSP IC)	Memory-expansion port, I/O connector for custom daughter boards	5V at 10 to 20W
	320/PC-15	8-bit ISA bus	20-MHz TMS320C15	256×16 (data)	4k×16 dual port to ISA bus	4k×16 (on DSP IC)	12-bit analog, four 16-bit parallel	5 and 12V at 10W
	320/PC-17	Daughter board for 320/PC-15	20-MHz TMS320C17	256×16 (data)	4k×16 dual port to ISA bus	4k×16 (on DSP IC)	12-bit analog	5V at 2W

NA=not available

Host interface	Software-development tools	Benchmarks			Price	Additional board features
		1024-point complex FFT (msec)	Matrix multiplication (μsec)	FIR filter (μsec/tap)		
I/O mapped, DSP IC's host port connects to host bus, DMA	ASM-320 macroassembler; PDS-320 program software; FFT subroutines	16	1.8 (3×3)	NA	$595	14-bit TLC32040 A/D and D/A converter on one IC samples at 19.2 kHz.
DMA	Bug-56 symbolic debugger; ASM-56 macroassembler; DSPtalk; Motorola assembler and simulator; Motorola C compiler; Hyperception's Hypersignal software	1.49	1.2 (3×3)	0.08	$2995	Two 16-bit Motorola S6 A/D converters; 16-bit AD1856 A/D converter; SCSI port.
DMA	ASM-320 macroassembler; PDS-320 program; FFT subroutines; signal-to-disk interface system; FFT libraries; filter program	16	1.8 (3×3)	NA	$2495	Two 16-bit Sony 20018 A/D converters; 16-bit PCM53KP-V D/A converter; 16-bit timer/counter.
DMA and interrupt control	Bug-56 symbolic debugger and monitor; assembler and linker; library for HP-UX; Basic and Pascal drivers	1.49	1.2 (3×3)	0.08	$2400	
DMA	D3EMU symbolic debugger; AT&T's assembler and debugger; AT&T's C compiler filter program	3.37	3.2 (3×3)	1.18+ 0.08	$3995	Two 16-bit Motorola 56 A/D converters; two 16-bit AD1856 D/A converters; SCSI port.
NA	Bug-56 symbolic debugger; ASM-56 macroassembler; DSPtalk; Motorola assembler and simulator; Motorola C compiler; Hyperception's hypersignal software	1.49	1.2 (3×3)	0.08	$595	14-bit TLC32040 A/D and D/A converter on one IC that samples at 12.2 kHz.
NA	Debugger; signal acquisition and editing; filter program; assembler	13.82	9 (3×3)	0.11	$1295	12-bit ADC80AG2-12 A/D converter; 12-bit DAC811 D/A converter; 8254 timer/counter.
DMA	Debugger, signal acquisition and editing; filter program; assembler	9.95	6.48 (3×3)	0.08	$2595	Optional 16-bit TLC32040 A/D and D/A converter on one IC that samples at 200 kHz.
DMA via dual-port memory, shared memory, data register	Spectron Microsystems' SPOX real-time OS; Texas Instruments' C compiler	3	4.86 (3×3)	0.06	$5995 (128k×8 memory)	Optional dual 16-bit A/D and D/A daughter card at 200 kHz.
Located on 16k-byte boundaries, interrupt control	Debugger; signal acquisition and editing; filter program; assembler	NA	12.96 (3×3)	0.32	$1995	12-bit ADC80AG2-12 A/D converter; 12-bit DAC811 D/A converter; 8254 timer/counter.
NA	Debugger; signal acquisition and editing; filter program; assembler	NA	12.96 (3×3)	0.32	$895	Optional 2917 codec.

Table continued

Table 1—Representative plug-in DSP boards *(continued)*

Company	Model	Bus compatibility	DSP IC	On-chip RAM (bits)	Onboard RAM (bits)	ROM (bits)	I/O ports	Power
Burr-Brown	ZPB3211/ ZPB3212	VMEbus	50-MHz DSP32C (ZPB3211), 2- to 50-MHz DSP32C (ZPB3212)	1.5k×32	16×32 (ZPB3211), 32k×32 (ZPB3212)	1k×32 (on DSP IC)	Serial, parallel	5V at 22.5W
	ZPB32/ ZPB32-HS	8-bit ISA bus	16-MHz DSP32 (ZPB32), 25-MHz DSP32 (ZPB32-HS)	1k×32	16k×32	512×32 (on DSP IC)	Serial at 8M bps (10M bps for ZPB32-HS), parallel	5V at 10W
	ZPB34	16-bit ISA bus	50-MHz DSP32C	1.5k×32	16k×32 to 144k×32	1k×32 (on DSP IC)	Serial at 10M bps, parallel	5V at 17.5W
	ZPB3201/ ZPB3202	VMEbus	25-MHz DSP32 (ZPB3201), two 25-MHz DSP32 (ZPB3202)	1k×32	16k×32 (ZPB3201), 32k×32 (ZPB3202)	512×32 (on DSP IC)	Serial, parallel	5V at 12.5W
C&C Technology	Vector 32	8-bit ISA bus	24-MHz DSP32	1k×32	14k×32	512×32 (on DSP IC)	Expansion connector for data-acquisition cards (12M-bps DMA transfers)	5V
	Vector 32C/256	16-bit ISA bus	50-MHz DSP32C	1.5k×32	64k×32	1k×32 (on DSP IC)	Expansion connector for data-acquisition cards (16M-bps DMA transfers)	5V
	Vector 32C/8500	16-bit ISA bus	50-MHz DSP32C	1.5k×32	128k×32 to 2M×32	1k×32 (on DSP IC)	16M-byte/sec serial	5V
Communications Automation & Control	XN1-B0	8-bit ISA bus	16-MHz DSP32	1k×32	256k×32	512×32 (on DSP IC)	8M-bps serial	5, 12, and −12V at 2.5W
	AC5-ax-J	16-bit ISA bus	50-MHz DSP32C	1.5k×32	64k×8 to 1.25M×8	1k×32 (on DSP IC)	14-bit analog	5 and 12V at 3W
	VEC32C-8500	16-bit ISA bus	50-MHz DSP32C	1.5k×32	8.5M×8	1k×32 (on DSP IC)	Serial	5V
Dalanco Spry	Model 10	8-bit ISA bus	TMS320C10	144×16 (data)	8k×8 dual port to ISA bus	1.5k×16 (on DSP IC)	I/O bus for daughter board	5V at 5W
	Model 25	8-bit ISA bus	40-MHz TMS320C25	288×16 (data), 256×16 (program or data)	8k×8 dual port to ISA bus (program)	4k×16 (on DSP IC)	I/O bus for daughter board	5V at 5W
DSP Design Tools	DSP32C-AT	16-bit ISA bus	50-MHz DSP32C	1.5k×32	64k×8 or 256k×8	1k×32 (on DSP IC)	16-bit analog	5V
DSP Research	Tiger 30	16-bit ISA bus	33-MHz TMS320C30	2k×32 (program or data), 64×32 (program cache)	256k×32 max	4k×32 (on DSP IC)	Two 8.3M-bps serial SCSI, memory expansion, two 14-bit analog	5V at 15W

NA=not available

Host interface	Software-development tools	Benchmarks			Price	Additional board features
		1024-point complex FFT (msec)	Matrix multiplication (μsec)	FIR filter (μsec/tap)		
NA	AT&T assembler and linker; AT&T C compiler, debugger, and monitor; DSplay XL software	5.7 for each DSP IC	6.9 (3×3) for each DSP IC	0.16 for each DSP IC	$3495 (ZPB3211), $5495 (ZPB3212)	Optional 12-bit 10-MHz and 16-bit 150-kHz analog-I/O boards.
I/O mapped	AT&T assembler and linker; AT&T C compiler, debugger, and monitor; DSPlay XL software	8.9, 5.7 for ZPB32-HS	10.35 (3×3), 6.9 (3×3) for ZPB32-HS	0.25, 0.16 for ZPB32-HS	$995 (ZPB32), $1495 (ZPB32-HS)	Optional 12-bit 10-MHz and 16-bit 150-kHz analog-I/O boards.
I/O mapped	AT&T assembler and linker; AT&T C compiler, debugger, and monitor; DSPlay XL software	3.2	3.2 (3×3)	0.08	$1995 to $4995 (depending on memory)	Optional 12-bit 10-MHz and 16-bit 150-kHz analog-I/O boards.
NA	AT&T assembler and linker; AT&T C compiler, debugger and monitor; DSPlay XL software	5.7 for each DSP IC	6.9 (3×3) for each DSP IC	0.16 for each DSP IC	$2995 (ZPB3201), $4495 (ZPB3202)	Optional 12-bit 10-MHz and 16-bit 150-kHz analog-I/O boards.
NA	Pascal, Basic, and C compilers; Fortran and C libraries; AT&T assembler, simulator, and debugger	8.96	12.5 (4×4)	0.16	$1095	Optional 12-bit A/D and D/A cards sample at 100 or 300 kHz.
NA	Pascal, Basic, and C compilers; Fortran and C libraries; AT&T assembler, simulator, and debugger	3.3	0.7 (3×3) × (3×1)	0.08	$2395	Optional 12-bit A/D and D/A cards sample at 100 or 300 kHz.
NA	Pascal, Basic, and C compilers; Fortran and C libraries; AT&T assembler, simulator, and debugger	3.3	0.7 (3×3) × (3×1)	0.08	$4745 (128k bytes of SRAM) (8M bytes of DRAM)	Optional 12-bit A/D and D/A cards sample at 100 or 300 kHz.
I/O mapped	AT&T assembler and simulator; AT&T math library; AT&T C compiler; D3EMU debugger; runtime library	14	7 (3×3)	0.25	$795	8-bit codec with phone jack.
I/O mapped	AT&T assembler and simulator; AT&T math library; AT&T C compiler; D3EMU debugger; runtime library	3.37	3.2 (3×3)	0.08	$2395 to $4990	Two 16-bit PCM78P A/D converters; two 16-bit PCM56P D/A converters.
I/O mapped	AT&T assembler and simulator; AT&T math library; AT&T C compiler; D3EMU debugger; runtime library	3.37	3.2 (3×3)	0.08	$6745	
Memory mapped, interrupt control	Assembler; debugger; FFT and filter programs	70	10 (3×3)	0.32	$750	Three 16-bit timer/counters; optional 12-bit 40-kHz A/D and D/A daughter boards.
Memory mapped, interrupt control	Assembler; debugger; FFT and filter programs	40	5 (3×3)	0.1	$895	Three 16-bit timer/counters; 12-bit 110-kHz HI1-774 or AD774 A/D converter; 12-bit AD667 D/A converter.
I/O mapped	Window-based debugger	NA	NA	NA	$2395 to $2995	Two 16-bit A/D and D/A converters sample at 50 kHz.
16k×8 dual-port memory mappable from COOO to FFFF, DMA	Window-based C source-level debugger; SPOX; assembler and linker; C compiler; Borland turbo-C library	2.6	NA	0.06	$4195	Two 14-bit TLC32044 A/D converters; two 14-bit TLC32044 D/A converters; Western Digital WD33C93A SCSI controller for SCSI port.

Table continued

Table 1—Representative plug-in DSP boards *(continued)*

Company	Model	Bus compatibility	DSP IC	On-chip RAM (bits)	Onboard RAM (bits)	ROM (bits)	I/O ports	Power
Future Digital Systems	VASP-16	VMEbus	TMS320C25 and four 25-MHz ZR34161	288×16 (data), 256×16 (program or data)	8k×16 max (program), 64k×16 max (data)	4k×16 (on DSP IC)	Datacube's 20M-byte/sec Maxbus	5V at 17.5W
Impact Technologies	Viper 8704	VMEbus	30-MHz ZR34161	128×16 (real data), 128×16 (image data)	128k×8 (program), 128k×8 (data), 1M×8 dual port to VMEbus	1024×16 (sine and cosine look-up table), 4M×8 max	Two RS232-C 66M-byte/sec P2 connectors (80M and 100M bytes/sec are optional)	5, 12, and −12V at 2.5W
Mathematical Systems Design	RTP-25/102	Multibus I	TMS320C25	288×16 (data), 256×16 (program or data)	64k×16 (program), 64k×16 (data)	4k×16 (on DSP IC)	Two 16-bit parallel	5V at 25W
Micro Industries	MIB II 32025	Multibus II	Four 40-MHz TMS320C25	288×16 (data), 256×16 (program or data)	1k×8 (for each DSP IC)	16k×8 (for each DSP IC), 4k×16 (on DSP IC)	16-bit analog output, two 16-bit digital	5, 12, −12, 20, and −20V at 25W
Microstar Laboratories	DAP2400	8-bit ISA bus	20-MHz DSP56001	512×24 (program), 512×24 (data)	32k×24	32×24 (on DSP IC), 128k×8 (on board)	16-channel analog input, 2-channel analog output, 16-channel digital input, 16-channel digital output, serial RS232-C	5V at 15W
Pacific Cyber/Metrix	DSP-2	VMEbus (board set)	33-MHz TMS320C30	2k×32 (program or data), 64×32 (program cache)	512k×8 (for each DSP IC), 512k×8 (global memory)	4k×32 (on DSP IC)	VSBbus, two 33M-byte/sec 32-bit parallel	5V at 30W
Rapid Systems	R325	16-bit ISA bus	40-MHz TMS320C25	288×16 (data), 256×16 (program or data)	64k×8	4k×16 (on DSP IC)	Audio jacks, optional multiple-board communication link	5V
Sky Computers	Challenger-C30	VMEbus	Two 33-MHz TMS320C30	2k×32 (program or data), 64×32 (program cache)	256k×8 (for each DSP IC), 8M×8 max (global memory)	4k×32 (internal to DSP IC)	Serial and parallel for each DSP IC	NA
Sonitech International	Spirit-30	16-bit ISA bus	33-MHz TMS320C30	2k×32 (program or data), 64×32 (program cache)	32k×32	4k×32 (on DSP IC), 128k×8 option on board	Two 8M-bps serial, 8M-word/sec parallel, memory-expansion connector	5V at 2.5W
Spectral Innovations	Mac DSP16K-04	16-bit Macintosh Nubus	25-MHz DSP32	1k×32	64k×8	512×32 (on DSP IC), configuration ROM	Two 12M-bps serial ports with DMA, daughter-card connector	5V at 20.5W
	Mac DSP 256KC	16-bit Macintosh Nubus	50-MHz DSP32C	1.5k×32	256k×8	1k×32 (on DSP IC), configuration ROM	Two 16M-bps serial ports with DMA, daughter-card connector	5V at 13.5W
Spectrum Signal Processing	DSP56001 VMEbus board	VMEbus	20-MHz DSP56001	512×24 (program), 512×24 (data)	8k×24 (program), 16k×24 (data)	32×24 (on DSP IC)	Two 16-bit analog, RS232C port, synchronous 5M-bps serial	5, −5, 12, and −12V at 13W

NA=not available

Host interface	Software-development tools	Benchmarks			Price	Additional board features
		1024-point complex FFT (msec)	Matrix multiplication (μsec)	FIR filter (μsec/tap)		
A32/A24/D16 slave, 5M-byte/sec DMA controller	Assembler; C compiler	0.82 integer, 1.2 block floating point	NA	NA	NA	
A16/A24/A32/D16/D32 master or slave	Assembler; monitor and debugger; C cross-compiler	0.75	2.5 (3×3)	0.6	\$10,000 to \$16,000	25-MHz 68030 CPU handles task arbitration and VMEbus interface.
NA	Assembler; simulator; in-circuit emulator	NA	NA	0.1	\$5000 to \$6000	
Message-passing coprocessor, RQA/RQP D16 interface, parallel system bus	NA	NA	NA	NA	\$6000	8751 microcontroller for serial-port control
NA	Company's DAPL OS, filter program, DAPview real-time graphics	5	NA	0.1	\$2395 to \$3195	16-MHz 80C186 μP; 12-bit 250-kHz Maxim162 A/D converter; two 12-bit DAC1201 D/A converters; three 16-bit timer/counters.
80M-byte/sec DMA controller	Data-flow operating system called FLOS; C compiler; DSP library; assembler and linker	NA	NA	NA	\$11,448	20-MHz 68030 CPU and 6882 floating-point unit assign tasks to DSP IC and VMEbus interface.
I/O mapped, DMA, optional host-communication FIFO buffer to ISA bus	Menu-driven DSP program; assembler, linker, and C compiler	NA	NA	NA	\$2995	Optional bidirectional FIFOs for pipelining multiple boards; optional analog-I/O input modules.
VMEbus master or slave	Spectron Microsystems' SPOX real-time OS; Sun device drivers; debugger	NA	NA	NA	\$11,750	
NA	EDSP debugger; SPOX OS; C library; runtime library; signal plotting; C compiler; assembler and linker	1.6	0.8 (3×3)	0.06	\$2895	Digital I/O card provides VMEbus, Macintosh II, PS/2, and Multibus II host-computer communication at 2M to 4M bytes/sec.
1.5M-byte/sec Nubus (DMA optional)	DSP32 assembler and linker; simulator; C compiler; array-processor library	NA	NA	NA	\$2995	Optional 16-bit 500-kHz analog I/O and 12-bit 32-kHz to 1-MHz data-acquisition daughter cards.
5M-byte/sec Nubus (DMA optional)	DSP32C assembler and linker; simulator; C compiler; array-processor library	NA	NA	NA	\$5995	Optional 16-bit 500-kHz analog I/O and 12-bit 32-kHz to 1-MHz data-acquisition daughter cards.
A16/D8 slave, A24/D8/D16/D32 master	C compiler; assembler and linker; window-based debugger and monitor; Unix drivers	NA	NA	NA	\$5995	Two 56200 FIR filter processors; two 16-bit 153-kHz PCM78 A/D converters; two 16-bit PCM56 D/A converters; stereo analog-I/O jacks; 16-bit timer/counter.

Table continued

Table 1—Representative plug-in DSP boards *(continued)*

Company	Model	Bus compatibility	DSP IC	On-chip RAM (bits)	Onboard RAM (bits)	ROM (bits)	I/O ports	Power
Spectrum Signal Processing	ADSP2101 system board	8-bit ISA bus	12.5-MHz ADSP2101	2k×24 (program), 1k×16 (data)	8k×24	Socket for 32×8 EPROM	Analog, 16-bit DSP link, two serial	5V at 6W
	DSP32C system board	16-bit ISA bus	50-MHz DSP32C	1.5k×32	40k×8	1k×32 (on DSP IC)	Analog, synchronous 16M-bps serial, 16-bit link (12.5M words/sec)	5, 12, and −12V at 6W
	DSP56001 system board	8-bit ISA bus	20-MHz DSP56001	512×24 (program), 512×24 (data)	16k×24 (program), 32k×24 (data)	32×24 (on DSP IC)	Synchronous 5M-bps serial, asynchronous 2.5M-bps serial, 16-bit DSP link (5M words/sec)	5V at 6.5W
	ADSP2100 system board	8-bit ISA bus	40-MHz ADSP2100	None	8k×24	None	Analog, 16-bit DSP link (5M words/sec)	5, 12, and −12V at 1W
	TMS320C30 real-time system	16-bit ISA bus	33-MHz TMS320C30	2k×32 (program or data), 64×32 (program cache)	172k×16 (local memory), 64k×16 dual port to ISA bus	4k×32 (on DSP IC)	Two 8.3M-bps serial, 16-bit DSP link (5M words/sec), analog, memory-expansion port	5, −5, and 12V
	TMS320C25 data-acquisition processor	16-bit ISA bus	40-MHz TMS320C25	288×16 (data), 256×16 (program or data)	64k×16 (data), 64k×16 (program), 16M×16 (buffer memory for buffer-management unit)	4k×16 (on DSP IC)	5M-bps serial, 16-bit DSP link (5M words/sec), buffer-management unit	5V at 5W
Symmetric Research	TMS320C25 coprocessor board	8-bit ISA bus	40-MHz TMS320C25	288×16 (data), 256×16 (program or data)	32k×8	4k×16 (on DSP IC)	16-bit parallel, serial	5V at 2.5W
	DSP32C coprocessor board	16-bit ISA bus	50-MHz DSP32C	1.5k×32		1k×32 (on DSP IC)	32-bit parallel, serial	5V at 7.5W
Transformation Systems	Racer Series	VMEbus	50-MHz DSP32C	1.5k×32	32k×8 or 128k×8 of SRAM; 1M×8, 4M×8, or 16M×8 of DRAM	1k×32 (on DSP IC)	16M-bps serial with DMA, 16-bit parallel with DMA, 2k×32-bit FIFO port with 40M-byte/sec transfer rate	5V at 30W
Valley Enterprises	VE-32C-01V and VE-32C-41V	VMEbus	50-MHz DSP32C ICs on one board	1.5k×32	256k×16 max (VE-32C-41V), 64k×16 max (VE-32C-01V)	1k×32 (on DSP IC)	2k×16 (41V) or 1k×16 (01V) FIFO input from P2 connector, 16-bit output, four 16M-bps serial	5V at 18W
Zoran	ZR73650 IEB	16-bit ISA bus	10-MHz ZR34161	128×16 (real data), 128×16 (image data)	32k×16 (program), 2k×16 (data for DSP use), 896k×8 (for 80286 use)	1024×16 (sine and cosine look-up table)	None	5V at 10W
	ZR73401 VSPD	16-bit ISA bus	20-MHz ZR34161	128×16 (real data), 128×16 (image data)	64k×16, 512×16 (FIFO to ISA bus)	1024×16 (sine and cosine look-up table)	512×16-bit FIFO input, 512×16-bit FIFO output	5V
	ZR73411 VSPE	16-bit ISA bus	20-MHz ZR34161	128×16 (real data), 128×16 (image data)	16k×8	1024×16 (sine and cosine look-up table)	None	5V at 5W

NA=not available

Host interface	Software-development tools	Benchmarks			Price	Additional board features
		1024-point complex FFT (msec)	Matrix multiplication (μsec)	FIR filter (μsec/tap)		
I/O mapped	Assembler and linker; debugger and monitor; DSP library	NA	NA	NA	$1995	14-bit 19.2-kHz codec.
I/O mapped	Assembler and linker; C compiler; window-based debugger and monitor	NA	NA	NA	$2995	Two 16-bit 153-kHz PCM78 A/D converters; two 16-bit PCM56 D/A converters; 16-bit timer/counter; internal or external triggering.
I/O mapped	Motorola C compiler, assembler, and linker; window-based debugger and monitor	NA	NA	NA	$2995	Intel 29C13 codec; two 16-bit 153-kHz PCM78 A/D converters; two 16-bit PCM56 D/A converters; internal and external triggering; 16-bit timer/counter.
I/O mapped	Assembler and linker; PROM file generator; simulator; Texas Instruments' C compiler, debugger, and monitor	NA	NA	NA	$2595	12-bit 200-kHz AD7572 A/D converter; 12-bit AD667 D/A converter; 16-bit timer/counter; internal and external triggering.
I/O mapped	C compiler; assembler and linker; SPOX OS; window- and command-based debugging monitor	NA	NA	NA	$6995	Two 16-bit 153-kHz PCM78 A/D converters; two 16-bit PCM56 D/A converters; internal and external triggering.
I/O mapped	Macroassembler and linker; C compiler; debugger and monitor	NA	NA	NA	$2495	Buffer-management unit handles circular-buffer management, address generation, and data-comparison tasks, relieving DSP overhead. It extends the address range of the DSP IC to 24 bits.
Memory mapped	TI assembler ($150 option); monitor/debugger, system utilities, and C library	8.8	6.75 (3×3)	0.1	$900	
Memory mapped	DSPasm assembler; DSPmon monitor/debugger; DSPmath C library	3.8	3.2 (3×3)	0.08	$950	
A24/A32, D8/D16/D32 slave	DSP32C assembler and linker; simulator; C compiler; DSP library; remote diagnostics; Unix drivers	2.9	0.72 (3×3) × (3×1)	0.08	$4880 to $12,480	
A16, D16 slave	DSP32C assembler, linker, and simulator; C compiler; DSP library; Unix drivers	1	0.5 (3×3)	0.02	$8500 to $16,000	Front-panel status LEDs.
Memory mapped	Assembler; simulator; 80286 debugger and linker	1.7	22 (4×4)	4	$3995	10-MHz 80286 CPU.
Memory mapped, interrupt control	C-based linker and assembler; simulator can switch between real-time and simulation mode	2.6	33 (4×4)	4	$3000	
Memory mapped (board), two registers are I/O mapped	Assembler; debugger; system-level simulator	2.7	34 (4×4)	4	$1800	

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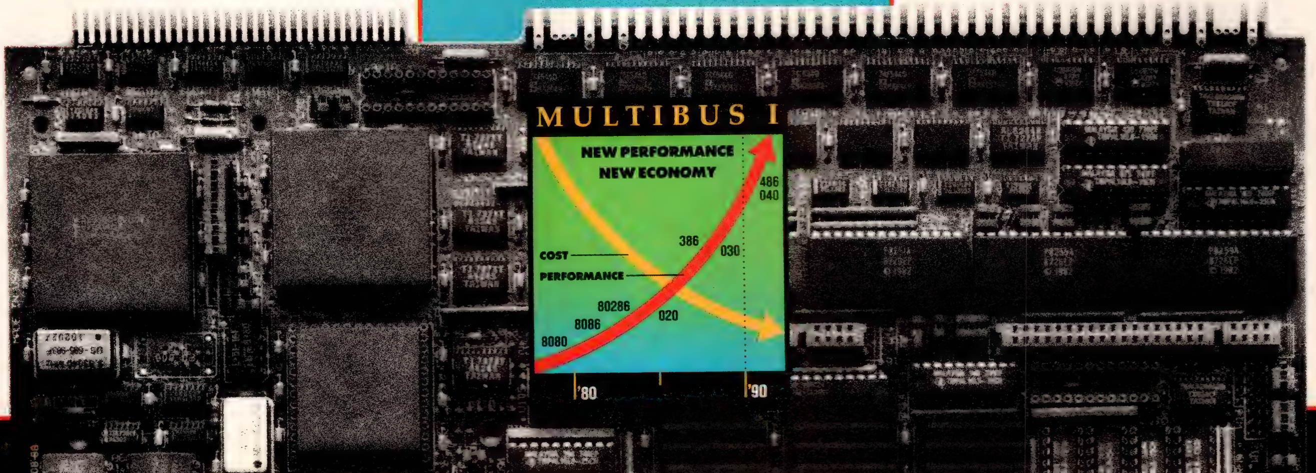

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Burr-Brown's World of

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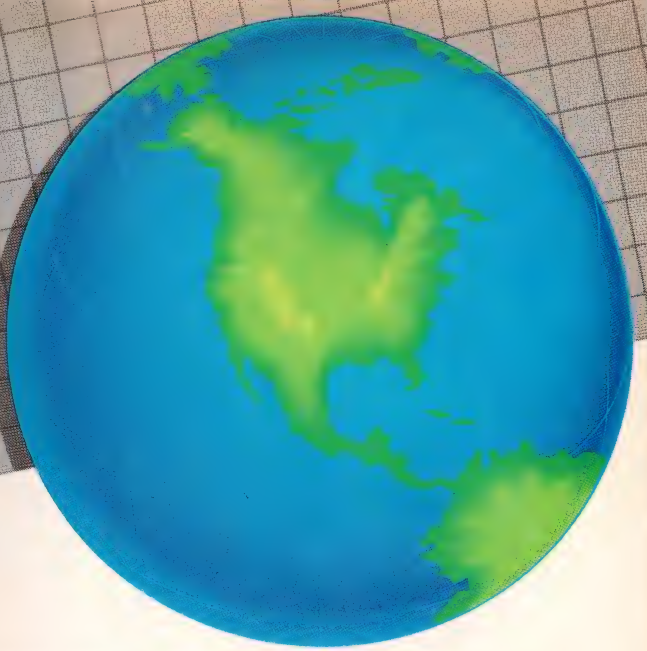
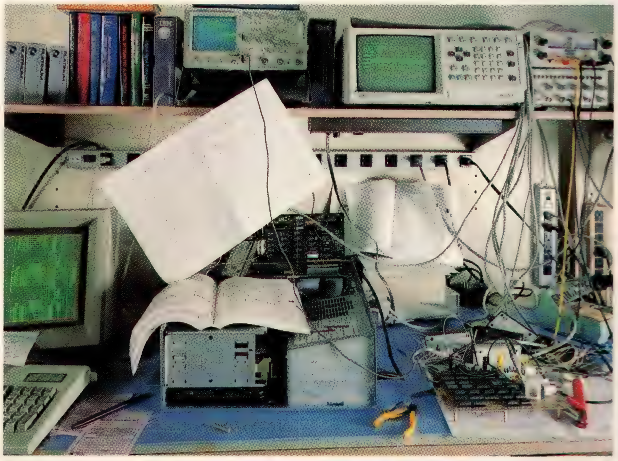
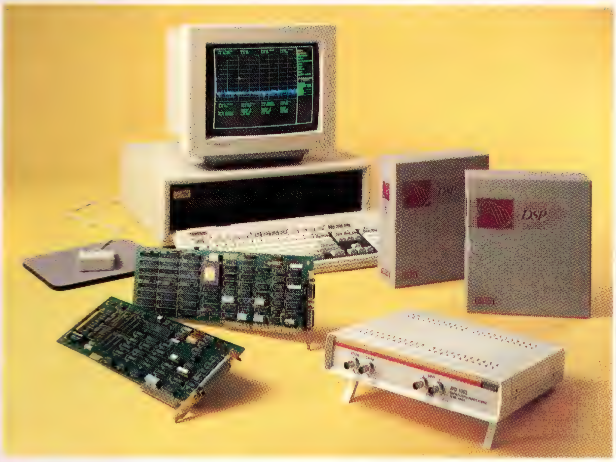


There Are Two Ways to Do DSP!



The Hard Way

- Time consuming
- Incompatibilities due to multiple vendors
- Unclear path from prototype to production
- Steep learning curve for software and hardware
- Uncertain results—room for doubt?



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- Easy-to-use, fully integrated system
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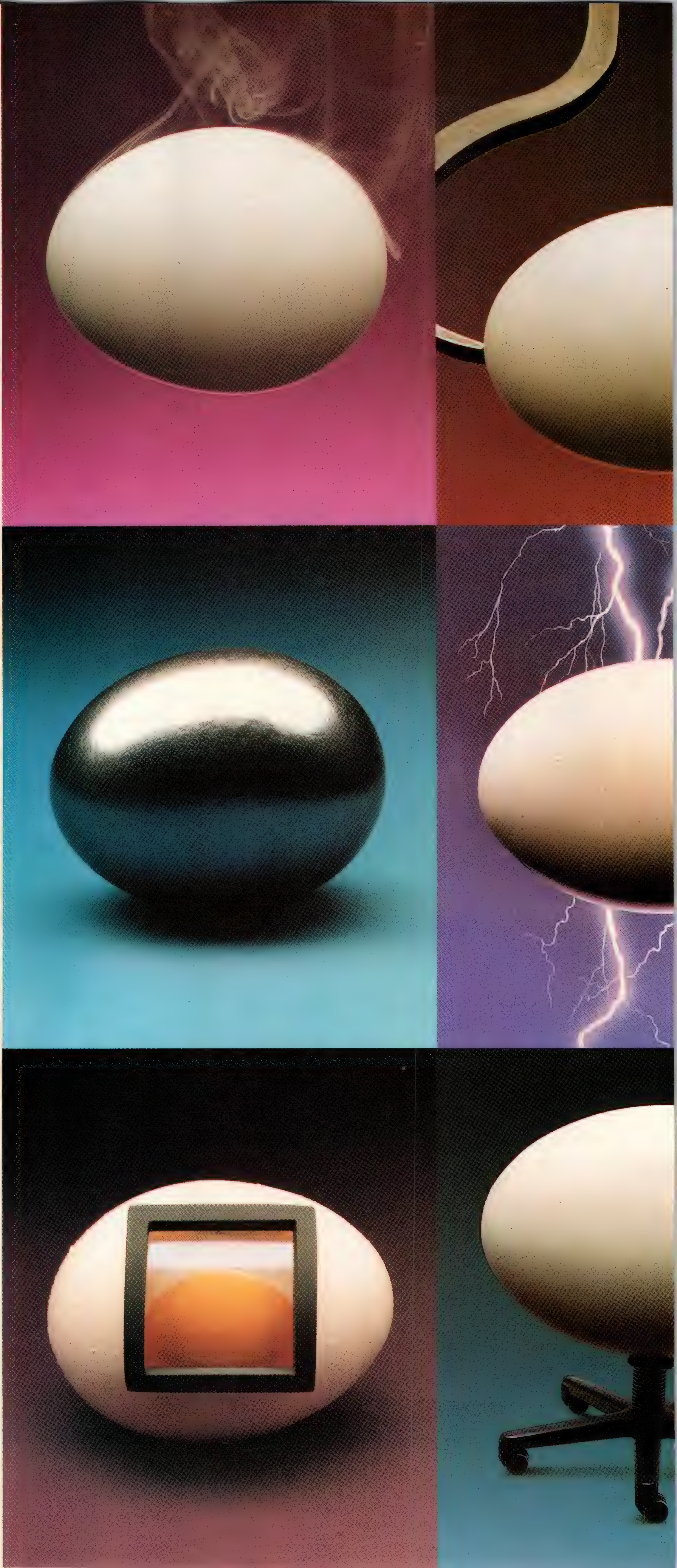

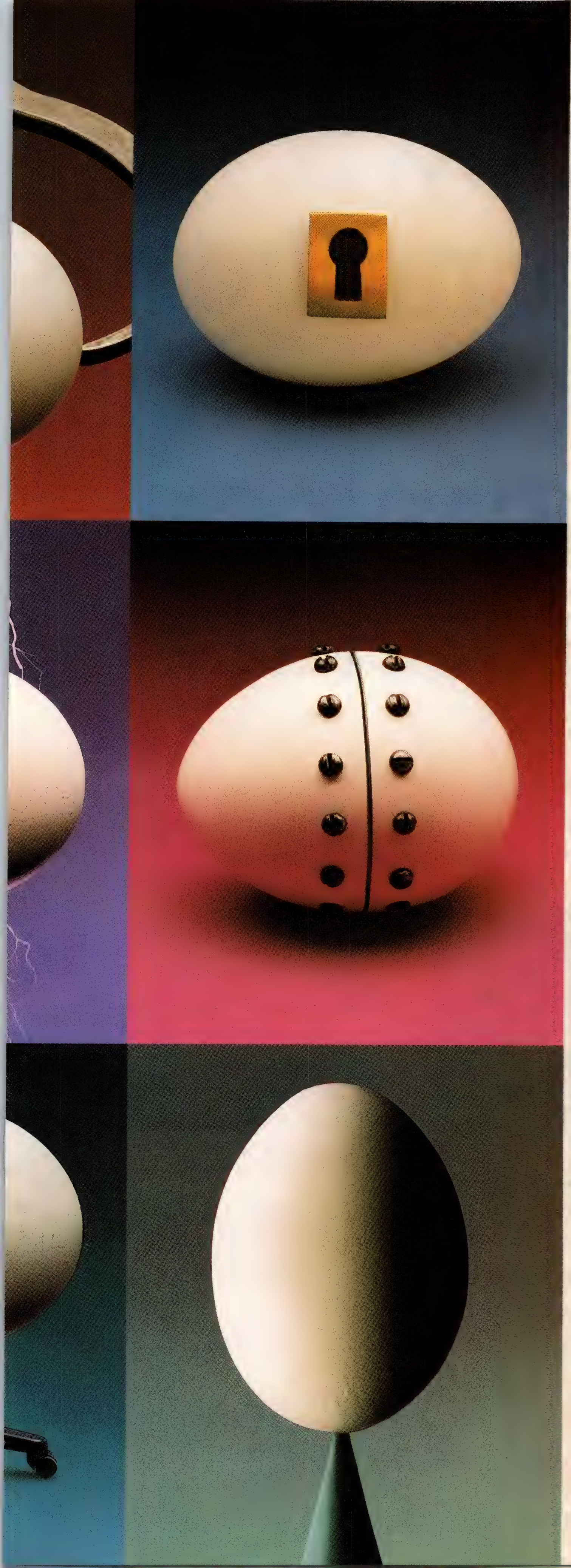

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The power product range from Ericsson has been putting on weight recently

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The new PLY: versatile 150-400W open frame switchers

PKY: 30-200W modules have standard pinning/footprint
(Note: Only available in Europe)

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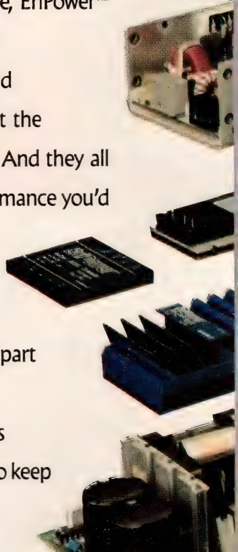

After all, as a part of one of the world's leading telecommunications companies, reliability is a vital part of our culture.

As you've probably realized, the EriPower™ range is expanding fast. Simply get in touch and we promise to keep you up to date, as we continue putting on weight.

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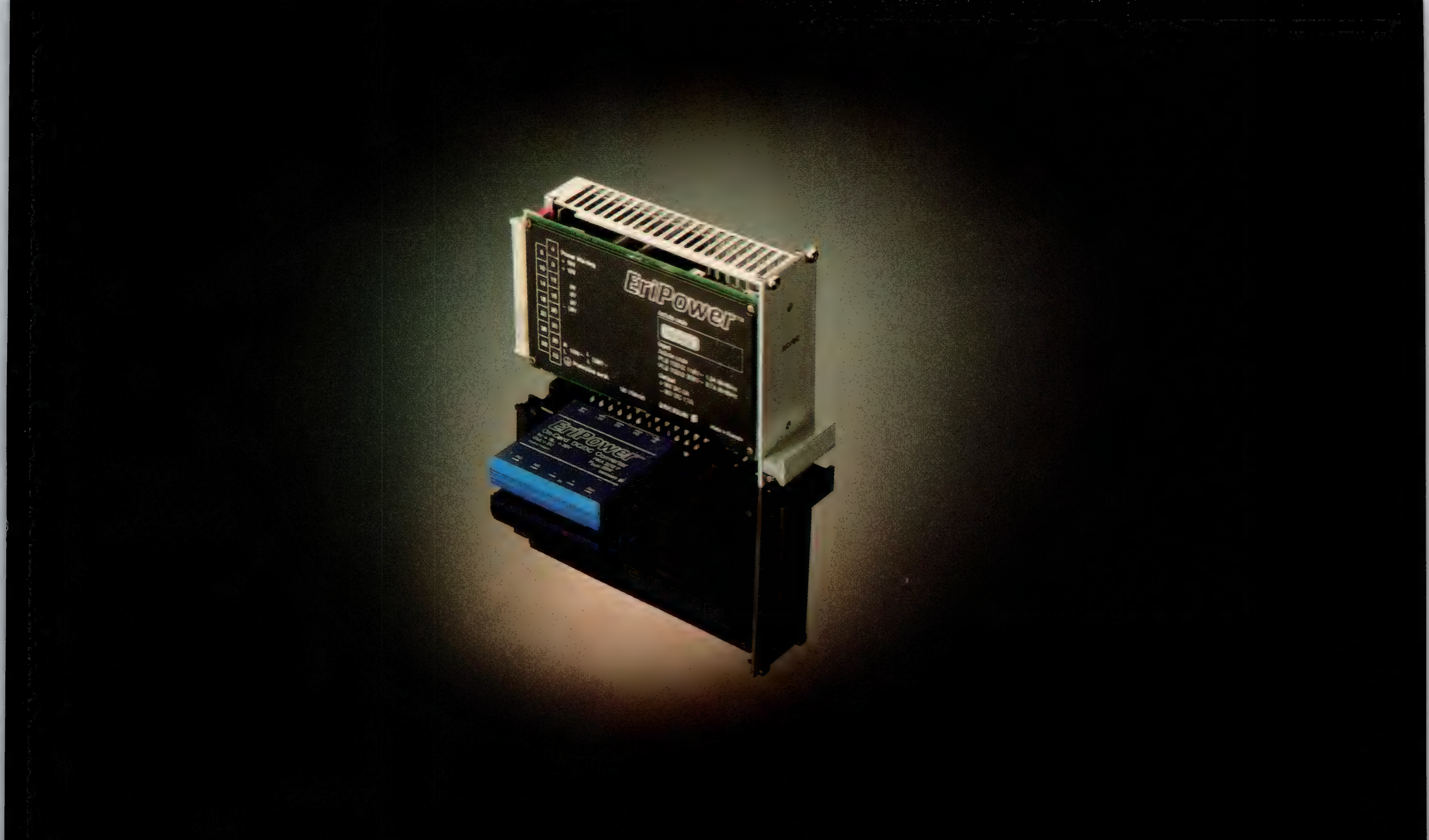
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1990

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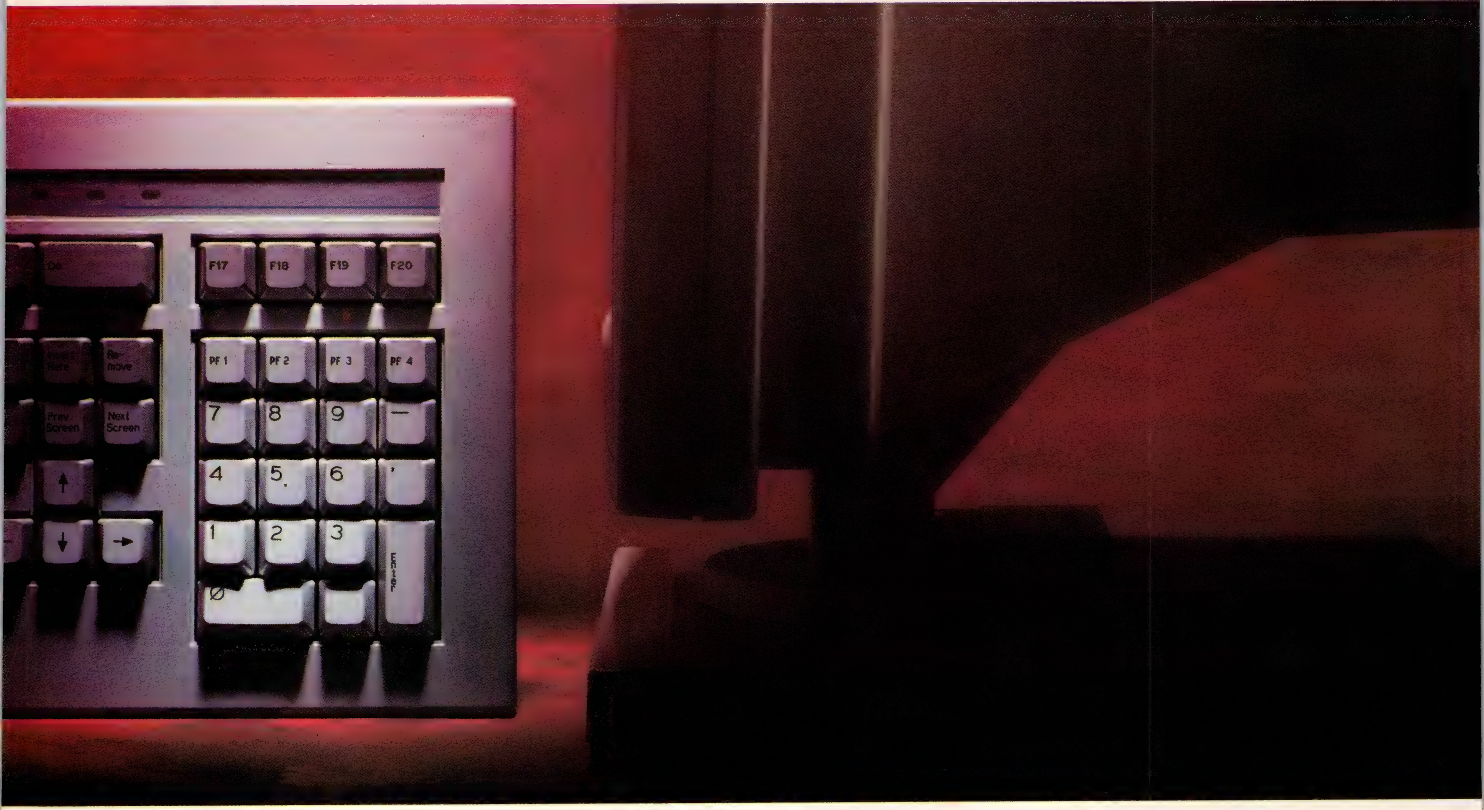

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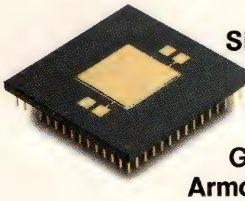

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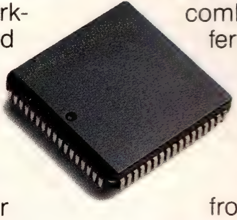

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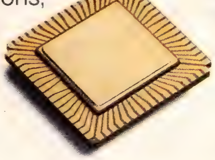

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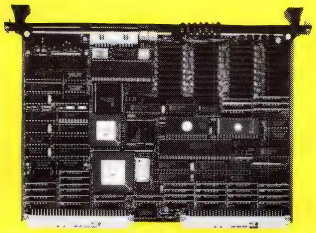
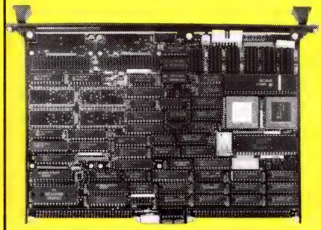


- 68020 12.5—33MHz, CPU
- 1-4 MB of dual-access, zero-wait-state DRAM with parity
- 68882 (optional)
- (2) 32-pin ROM sockets
- (2) RS232C serial ports
- (2) 8-bit parallel ports
- (1) OMNIMODULE socket for a wide variety of I/O (ie. 2 serial ports, 20 parallel lines)
- 4 level bus arbiter (optional)

OB68K/VSBCI™ VME SINGLE BOARD COMPUTER



- 68000 12.5MHz 16/32 bit CPU
- 512KB of dual-access, zero-wait-state DRAM with parity
- (4) 28-pin ROM sockets
- (3) 16-bit counter/timers
- (2) Omnimodule™ I/O sockets for a wide variety of I/O (ie. 4 serial ports, 40 parallel lines)
- DMA controller (optional)
- VME bus interrupt generator (optional)
- Optional 4 level bus arbiter
- Two year limited warranty

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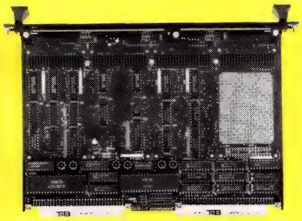
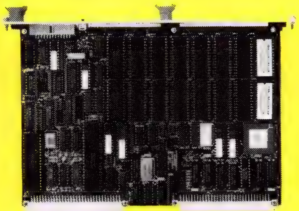


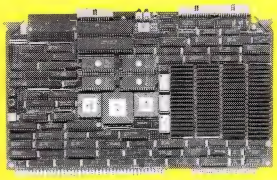
- (4) Omnimodule I/O sockets for a wide variety of I/O (ie. 8 serial ports, 80 parallel lines)
- One (1) interrupt per Omnimodule, two (2) optional

OB68K/VME1™ VME SINGLE BOARD COMPUTER



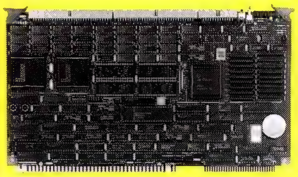
- 12.5MHz 68000 CPU
- (8) pairs of 28-pin sockets for RAM or ROM
- (2) RS-232C serial ports
- (2) 8-bit parallel I/O ports
- System controller

OB68K/MSBC30™ MULTIBUS I Single Board Computer



- 25-33 MHz 68030 CPU
- 4-32 MB dual access, zero-wait-state DRAM w/parity
- 68882 Math Co-Processor (optional)
- 2 channel DMA controller (optional)
- (2) RS232c sync/async serial ports
- (2) 8-bit parallel ports
- (1) OMNIMODULE™ socket
- (4) 32-pin ROM sockets

OB68K/MCOM1™ MULTIBUS I Intelligent 16-Port Serial I/O Board



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  - —on chip MMU
- (16) full duplex asynchronous RS232C ports with full modem control
- 2MB of dual-ported, zero-wait-state RAM with parity
- (4) 32 pin, JEDEC ROM sockets
- Battery back-up calendar clock
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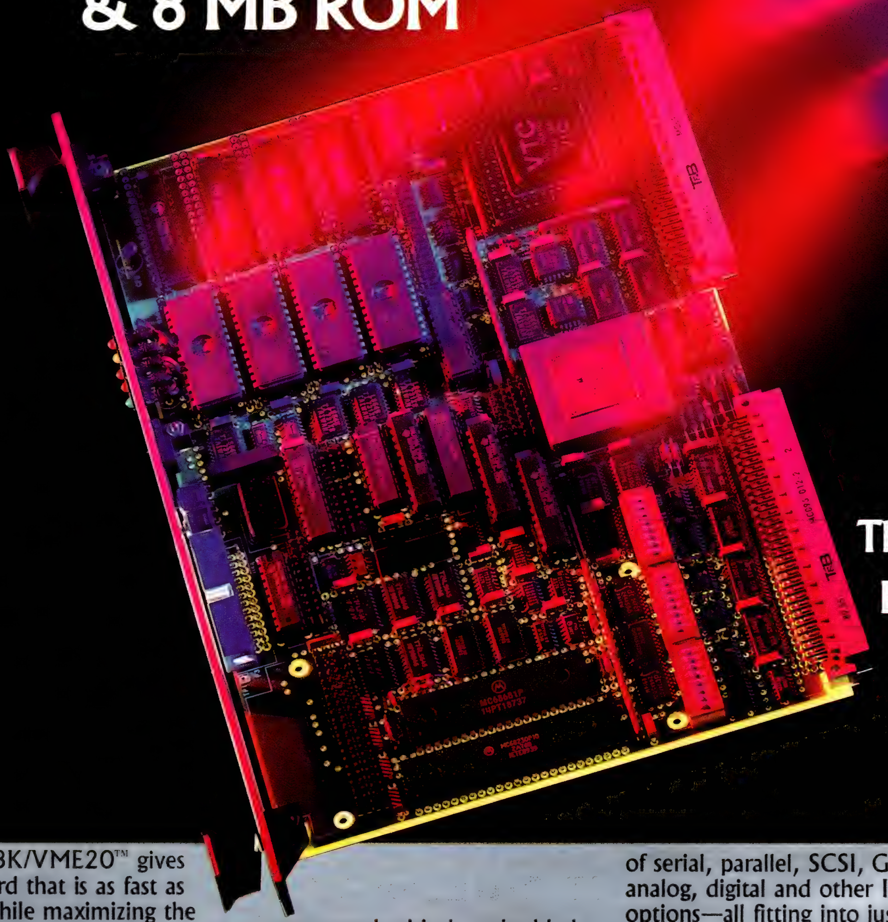
A Look at Today... A Vision of Tomorrow

VME 68020, 33MHz 0-Wait-State & 8 MB ROM



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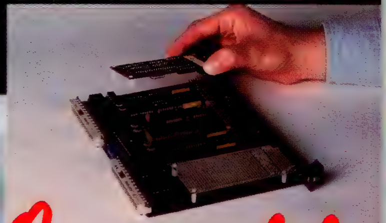

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EDN'S ALL-STAR PC

PART 4:

OPERATING-SYSTEM SOFTWARE

Just as a ballclub needs a pitcher and a catcher, EDN's All-Star PC needs software to be complete. The cardinal component of any software repertoire is the operating system. The All-Star PC uses several.

Operating systems get very little respect from users, probably because they get in your way more often than not. Cryptic commands and mysterious command-line switches make text-oriented operating systems difficult to use. Yet these essential programs define how you interact with your computer. Microsoft's DOS is currently the most popular PC operating system, but it isn't the only player available for high-end PCs like EDN's All-Star PC. Multitasking operating systems, including Unix and OS/2, are waiting in the on-deck circle.

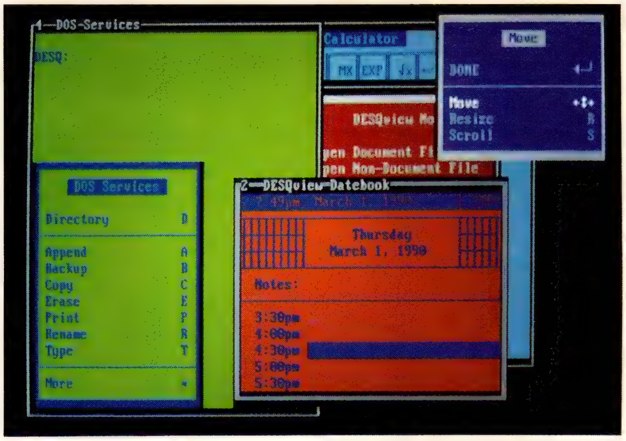
Many people think DOS is getting long in the tooth. DOS and the PC were introduced together in 1981 and both have since evolved. DOS 1.0 mimicked Digital Research's CP/M operating system, which ran on the 8080 μP. But DOS 2.0 gained a character all its own by incorporating hierarchical directories. The most recent release, DOS 4.01, overcomes many of the operating system's lingering limitations. It supports expanded memory, large hard disks, and a limited form of multitasking. The All-Star PC includes DOS 4.01 as one of its operating systems because of the many applications programs available for DOS-based systems.

DOS 4.01 allows the All-Star PC to use

STEVEN H LEIBSON,
Senior Regional Editor

the entire 315M bytes of the Seagate Wren Runner hard-disk drive as one physical disk drive. Earlier versions of DOS could handle logical drives no larger than 32M bytes. DOS 3.3 split each of the All-Star PC's 315M-byte Wren Runners into 10 logical drives, a shortcoming that caused problems with some programs. DOS 4.01's solution is much cleaner.

Since DOS's introduction, the industry's definition of just what an OS should provide has evolved. In the heyday of CP/M and DOS 1.0, most PCs had either limited or no graphics hardware. Consequently, the operating systems for these machines provided very little support. Now however, graphics displays are integral to most PCs. Yet DOS still shuns graphics support. It clings to the past because its existing base of applications programs can't take advantage of new graphics services. DOS 4.01 provides a graphics-shell program that creates the illusion of a graphical user interface (GUI), but the applications programs that you activate from that shell must supply their own graphics drivers, like any DOS program. As a result, every DOS applications program looks and acts differently. There's nothing inherently wrong with differentiation, but a wide-open operating environment like DOS extracts a penalty in user inefficiency and in learning time.



Though it cannot retrofit GUI standardization to existing DOS applications programs, Quarterdeck's DESQview 386 still manages to provide windowing and multitasking services.

Microsoft recognized years ago that DOS was falling short of contemporary operating-system expectancies, so it developed the Windows operating-system shell to add missing features. The earliest versions of Windows provided a standard set of graphics services that allowed applications programmers to produce software with a common look and feel. Unfortunately, Windows can only provide graphics services to programs that are specifically written to make use of them. No software shell can retrofit graphics on a program created ignorant of GUI concepts. But DOS programs still outnumber Windows applications programs by a substantial margin, so most existing PCs currently operate without the Windows GUI. This situation may change however, as more 80386- and 80486-based PCs enter the workplace. Windows/386 version 2.11, the latest and most powerful version of the package, runs DOS applications. With the added hardware boost from the 80386-µP family, it also provides memory management and multitasking services. Thus Windows/386 provides a bridge between existing DOS applications and a GUI-based OS: DOS plus Windows.

Quarterdeck Office Systems recognized the limitations inherent in DOS and took a different approach to enhancing DOS's capabilities. The company's DESQview 386 operating-system shell for DOS provides multitasking and windowing services like Microsoft's Windows/386. QEMM (the Quarterdeck expanded memory manager for the 80386) is part of the DESQview 386 package; it provides memory-management services for DESQview. With QEMM, you can convert all memory above the first megabyte into so-called expanded memory (called block-switched memory in the days of CP/M). Many DOS programs can take advantage of expanded memory for large data structures, and the DESQview shell uses expanded memory to provide multitasking under DOS. Windows/386 performs similar feats with expanded memory. However, unlike Windows/386, DESQview doesn't bestow a graphics-interface standard upon application programs. Instead, its windows differ greatly in appearance from one to the next, depending on the user interface built into the underlying program.

EDN's All-Star PC runs both Windows/386 and DESQview 386, but it can only run one at a time because both programs want to manage the system's memory, an event that would lead to conflicts if both operated concurrently. To use both, you must keep two different CONFIG.SYS files on your hard disk and place the one you

EDN's PC All-Stars

DOS 4.01

Microsoft Corp, Box 97017,
Redmond, WA 98073. (206) 882-8089.
Circle No. 650

BIO: DOS 4.01 is the latest version in a long line of PC operating systems. The DOS 4 series is the first version of the operating system to support logical drives and files larger than 32M bytes.

STATS:
PROCESSOR REQUIRED: 80X86-compatible μPs
FLOPPY-DISK SUPPORT: 5¼- and 3½-in. drives
HARD-DISK SUPPORT: 512M bytes/logical drive
EXPANDED MEMORY SUPPORT: LIM 4.0
APPLICATIONS INCLUDED: Graphics-system shell, editor, debugger, and linker

want in the root directory, then reboot your PC to activate the desired shell program. This procedure lacks any semblance of elegance, but it works.

Concurrency streamlines work

Windows/386 and DESQview 386 make PC users more efficient by allowing many programs to run concurrently. In such an environment, PC users can jump from program to program instantly as warranted by the day's tasks and by those pesky interruptions everyone deals with. Both programs also allow processing for background tasks, so you can initiate a long processing job and then switch to another task while the background processing occurs. Far too many people state that most PC users do not need and cannot take advantage of concurrent-program operation. That's bunk! Concurrent-program operation allows you to leave one task to handle an interruption and later return to the same spot. Everyone deals with interruptions on a daily basis, so it's foolish to say that few can benefit from the advantages provided by programs like DESQview 386 or Windows/386.

Software compilation, for example, greatly benefits from background processing. Software developers have used background compilation on minicomputers and mainframe computers for decades. A multitasking OS allows you to jump from a debugger to an editor to a compiler and back to the debugger. Similarly, a hardware designer can jump from a schematic-capture package to a simulator to a pc-board-layout package to a thermal-analysis package and back again. Engineers can very definitely benefit from concurrent-program operation and multitasking.

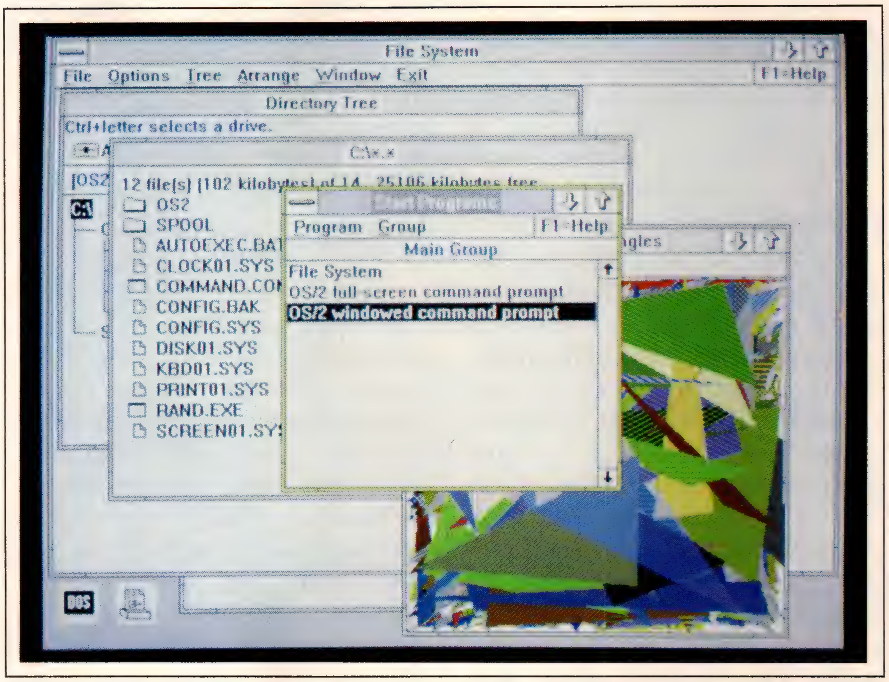
But DOS applications aren't really designed for multitasking environments and therefore lack features that could make them even more useful. For example, programs designed for a single-tasking environment aren't likely to contain facilities to communicate with other running programs. Only one program at a time can run under a single-tasking OS, so it would be silly to include such capabilities. Yet real-time communications among programs can be quite useful, particularly for engineering applications.

For example, a schematic-capture program can transmit design changes to a bill-of-materials program to a program that calculates power dissipation to still another program that calculates the project's component cost. The electronic-product-development tools in the latest software release from Mentor Graphics Corp (Beaverton, OR) do exactly that. However these tools, collectively called Software Release 8.0, currently run under

Accelerating system performance through GUIs

GUIs don't just help users make more efficient use of their machines. They can also make programs run faster through the use of graphics accelerators, such as the NEC Multisync Graphics Engine or the Hewlett-Packard IGC 20 discussed in Part 3. You can't easily boost a computer's overall performance with a graphics-accelerator card if every application program must be aware of the accelerator and know how to use it. Unfortunately, that is what must occur if you use unenhanced DOS.

However, if all application programs use standard graphics services from the OS, then only the operating system needs to be aware of the accelerator. Thus PC operating systems with GUIs, such as DOS with Windows, OS/2 with Presentation Manager, or Unix with Motif, can provide accelerated graphics to all application programs with only one set of display drivers installed in the operating system. An application program need not even be concerned about whether or not a graphics-accelerator card is installed in the system. If an accelerator is present the program will run faster. But that is the only operational difference.



Bearing a strong family resemblance to its cousin, Microsoft Windows/386, the Presentation Manager adds GUI capabilities to Microsoft's OS/2 operating system.

Unix and only on workstation-class computers. Without multitasking, you would need to run each program in turn to compute the various effects caused by the design changes. Because a collection of integrated application programs like Software Release 8.0 promises to provide a large jump in individual productivity, the PC market is girding for the jump to multitasking operating systems over the next two years.

Dueling operating systems

Unix and OS/2 are fighting for the lead as the PC multitasking operating system of choice. Most engineers have at least heard of Unix. Workstation and software vendors like Mentor made Unix the primary operating system for their technical applications. GUIs such as the Open Software Foundation's Motif metamorphose Unix from a hacker's delight into an OS that can be used by people with a wide range of computer skills. Intel claims, based on industry surveys, that almost 60% of Unix-based computer systems shipped annually now incorporate 80286 and 80386 μPs, and that many of those systems are PCs. Minicomputers, RISC-based products, and Motorola 68000-based computers constitute the remainder of the market. PCs are clearly a big part of the Unix world, although Unix currently represents only a small part of the PC's market.

For high-end PC's, OS/2 will be Unix's biggest competitor. OS/2 looks and operates a lot like DOS but provides additional capabilities such as multitasking. With the addition of the Presentation Manager GUI, OS/2 becomes a graphical OS that resembles the DOS/Windows combo. But OS/2 is strictly an OEM product for Microsoft; the company doesn't sell the operating system to end users, at least not yet. Currently, computer OEMs must use Microsoft's OS/2 development kit to build a custom-tailored version of OS/2 for their specific hardware configurations. Although earlier versions of OS/2 (through version 1.2) run on both 80286-and 80386-based computers, Microsoft's OS/2 version 2.0, currently available only in development-kit form, runs only on computers that employ μPs from the 80386 family.

In addition to multitasking, Unix and OS/2 provide another sorely needed feature: the ability to use more than 640k bytes of RAM for a program. This long-standing DOS-imposed limitation seemed inconsequential when DOS was first introduced. Compared to CP/M's 64k-byte limit, DOS's 640k-byte ceiling seemed vast. But software developers have made grand extensions to their products since 1981. They have attempted (and often succeeded) to take on tasks never thought possible on a PC. As a result, word processors have evolved into desktop-publishing packages, schematic-capture programs grapple with pc boards of ever increasing complexity, and some PLD compilers now attempt to fit designs into multiple devices. All of these added capabilities demand more

EDN's PC All-Stars **Windows/386 Version 2.11**

Microsoft Corp, Box 97017,
Redmond, WA 98073. (206) 882-
8089. **Circle No. 651**

BIO: Microsoft's Windows/386 adds a standard graphical user interface, multitasking, and memory management to DOS-based systems. It can run DOS application programs and programs designed for Windows.

STATS:
PROCESSOR REQUIRED: 80386 family
MEMORY REQUIRED: 2M bytes min
GRAPHICS-CARD SUPPORT: CGA, EGA, VGA, Hercules
APPLICATIONS INCLUDED: Windows write, Windows paint, calculator, notepad, calendar, card file

EDN's PC All-Stars **DESQview 386**

Quarterdeck Office Systems,
150 Pico Blvd, Santa Monica,
CA 90405. (213) 392-9701.
Circle No. 652

BIO: DESQview 386 provides multitasking, windowing, and memory management for DOS-based PCs. Its QEMM memory manager transforms extended memory (above the first megabyte) into expanded memory. It can also speed up ROM BIOS routines by moving them into RAM.

STATS:
PROCESSOR REQUIRED: 80386 family
GRAPHICS-CARD SUPPORT: Monochrome, CGA, EGA, VGA, Hercules
APPLICATIONS INCLUDED: Clip board, phone dialer
OPTIONAL APPLICATIONS: Notepad, calculator, datebook, communications

memory, so the 640k-byte barrier, once a liberating factor, has now become a constant stumbling block.

Both Unix and OS/2 circumvent DOS's 640k-byte limitation. By their inherent designs, they make use of the memory above the first megabyte as conventional (not extended or expanded) memory. Because Unix and OS/2 version 2.0 don't run on 8088- and 80286-based machines, they don't limit programs to the first megabyte of memory. In addition, both operating systems support virtual-memory operation, which permits applications programs to run as though there were more RAM in the system than is actually present. Virtual-operating systems load only the parts of a program that are required for immediate operations and leave unneeded sections of code on the system's disk until they are needed. Disk capacity becomes the new limiting factor for program size, and hard-disk drives are getting very big indeed.

Unix for the PC

EDN's All-Star PC runs two flavors of Unix—Xenix and Unix/386. Both are offered by the Santa Cruz Operation (SCO). Xenix is a compact version of Unix designed to operate on 80286- and 80386-based PCs. The stock version supports only two types of hard-disk controllers—the de facto standard Western Digital WD1003 controller for ST-506 hard-disk drives and Adaptec's AHA1540 SCSI-host-adapter family. The WD1003 doesn't work with SCSI-based disk drives, and, as discussed in Part 2, the Adaptec boards conflict with Quarterdeck's DOS-extension products. The solution, for Xenix, is to add a special Xenix driver for the IN-2000. Always Technology, the vendor that supplied the IN-2000 SCSI host adapter for the All-Star PC, finished a disk driver for SCO's Xenix just in time for this article.

SCO's Unix/386 is part of the company's Open Desktop package, which combines a version of Unix System V version 3.2, a PC version of Motif, and various standard networking and communications programs into one comprehensive product. Open Desktop is a very big operating system by PC standards. To run it, a PC needs at least 8M bytes of RAM and should have at least 100M bytes of hard-disk space available. Unlike Xenix, SCO's Open Desktop package runs strictly on PCs that employ μPs from the 80386 family.

The Open Desktop can share the hard disk with other operating systems, such as DOS and OS/2, through DOS's disk-partitioning scheme. However, you must use the respective operating systems' FDISK programs to activate a partition. The active partition determines which operating system will take over the next time the computer boots. SCO Xenix has a

"DOS" command that is supposed to switch a system over to DOS, but this command didn't work on the All-Star PC. Steven Katz, the vice president of software engineering at Always Technology, surmised that Unix's DOS command failed because it didn't recognize the large DOS 4.01 disk partition as a valid DOS partition. DOS 4.01's disk partition differs from the partitions created by older DOS vintages.

A tenuous, 3-way OS marriage

Trying to get DOS, OS/2, and Unix/386 to coexist on a hard disk on the All-Star PC presented several problems. The first was getting the right disk drivers for all three operating systems. OS vendors write their disk drivers for the PC's lowest common denominator: the WD1003. Any deviation requires a hard-disk driver to link the operating system to the "foreign" controller. The All-Star PC's IN-2000 incorporates a BIOS ROM that provides its own DOS driver, so no extra software is needed. Always also supplied a loadable driver for Xenix because Xenix does not use the BIOS ROM's disk-access routines. Because OS/2 and Unix also won't make use of the IN-2000's BIOS ROM, they too require disk drivers. As the deadline for this article approached, it appeared that Always Technology would not be able to supply OS/2 and Unix drivers for its board in time for this project.

Fortunately, Perceptive Solutions Inc (PSI) had just completed its first production run of Hyperstore 1600 disk controllers. The Hyperstore 1600 is a caching disk controller with interchangeable media adapters. It can operate ST-506-, ESDI-, and SCSI-based hard disks. The controller board accepts 4M bytes of dynamic RAM (DRAM) for its disk cache and employs a Zilog Z280 µP for SCSI and cache control. An auxiliary memory board can boost the controller's cache RAM to 20M bytes. The Hyperstore 1600 operates in either a native SSP (standard-storage-protocol) mode or a WD1003 emulation mode. PSI says that its SSP mode is slightly faster than the WD1003 mode. But, any PC operating system can use the emulation mode without additional disk drivers. The major drawback to emulation is that the WD1003 register-set definition limits the hard-disk capacity to two 450M-byte drives. Fortunately, that limitation presented no problems for the All-Star PC's two 315M-byte drives.

Though installing the Hyperstore 1600 presented few problems, there was one tough nut that had to be cracked—a conflict between the Hyperstore 1600's integral floppy-disk controller and the Compaticard IV card from Microsolutions, which was already in the All-Star PC. You can't disable the Hyperstore 1600's floppy-disk controller (although you can move it to a secondary address, which also conflicts with the Compaticard IV). As a result, the final configuration gives control of the All-Star PC's two 5¼-in. floppy-disk drives to the Hyperstore 1600 and retains the Compaticard IV for the two 3½-in. floppy-disk drives. In this configuration, the Hyperstore 1600 uses the primary floppy-disk-controller address, and the Compaticard IV occupies the secondary address.

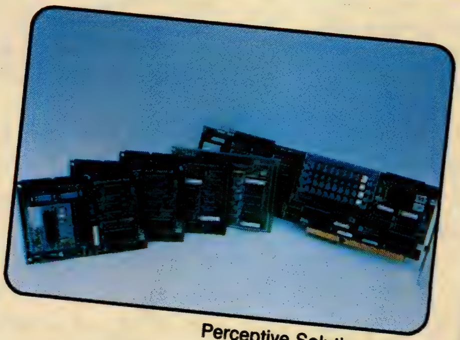
Tape-drive control became a problem when the Hyperstore 1600 entered the mix. Because I would

EDN's PC All-Stars **Hyperstore 1600 Disk Controller**

Perceptive Solutions Inc, 1509 Falcon, Suite 104, DeSoto, TX 75115. (214) 224-6774. FAX (214) 228-1430.

Circle No. 653

STATS:
BUS: IBM PC/AT
MEDIA ADAPTERS: ST506, ESDI, SCSI
MAXIMUM NUMBER OF MEDIA ADAPTERS: 4
MAXIMUM ON-CARD MEMORY: 4M bytes
MAXIMUM OFF-CARD MEMORY: 16M bytes
OPERATING MODES: WD1003 emulation, native SSP



Perceptive Solutions Inc

BIO: The Hyperstore 1600 combines flexible disk interfacing with intelligent caching on one PC/AT expansion card. Through WD1003 emulation, the disk controller offers wide compatibility with any PC operating system.

EDN's PC All-Stars — **Open Desktop**

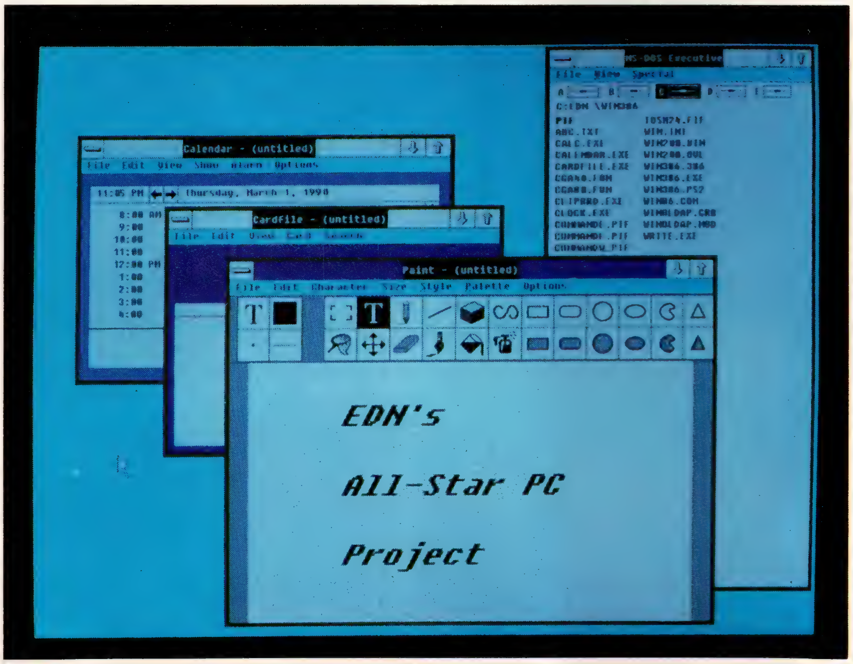
The Santa Cruz Operation
(SCO), Box 1900, Santa Cruz,
CA 95061. (408) 425-7222.
Circle No. 654

BIO: SCO's Open Desktop rolls all of the most contemporary Unix utility programs (operating system, graphical user interface, and network services) into one package for high-end PCs.

STATS:
PROCESSOR REQUIRED: 80386 family
OPERATING SYSTEM: Unix System V/386 Release 3.2
GRAPHICAL USER INTERFACE: X Window with Motif
NETWORK SERVICES: TCP/IP, NFS
RECOMMENDED MEMORY: 8M bytes RAM, 100M bytes disk
GRAPHICS-CARD SUPPORT: EGA, VGA, Hercules

be switching between the IN-2000 and the Hyperstore 1600, the All-Star PC needed a new tape-backup scheme. PSI has not yet developed tape drivers for its SCSI controller, and the Novastor tape-utility program supplied with the IN-2000 only works with the IN-2000. The addition of a third SCSI host adapter, Future Domain's TMC-860, solved the problem. Future Domain introduced drivers for the Sytos tape-backup program late last year and supplied that software for the All-Star PC project.

Sytos from Sytron Corp (Westboro, MA) is a general-purpose tape-backup utility. The Future Domain drivers link Sytos and the TMC-860 to the All-Star PC's Exabyte EXB-8200 cartridge-tape subsystem. Packing three SCSI host adapters into one PC is hardly an efficient configuration. One SCSI controller should be able to control all of the All-Star PC's SCSI-based mass-storage devices, but the TMC-860 is a bit slow for the Wren Runner disk drives, the IN-2000 has a limited repertoire of OS drivers, and the Hyperstore 1600 lacks tape drivers. The vendors of these SCSI host adapters will undoubtedly solve most of these problems in the near future, but for now, the All-Star PC must rely on the services of several SCSI host adapters to accomplish all of the project's goals.



With the proper display drivers, a high-resolution graphics accelerator like the NEC Multisync Graphics engine allows Microsoft Windows/386 to throw a lot of information onto the screen quickly.

Using either the IN-2000 or the Hyperstore 1600, DOS 4.01 and Windows/386 loaded easily. However, while using the Hyperstore 1600 to load either SCO's Open Desktop or Microsoft's OS/2 version 2.0, the All-Star PC locked up shortly after beginning the installation. As it turned out, neither problem was related to the Hyperstore 1600. Unable to solve the Unix and OS/2 installation problems alone, I took the All-Star PC and Steven Katz to Colorado Springs to visit Ron Sartore at Cheetah's R&D labs.

Sartore solved the Unix/386 problem in less than a day. Early in the installation process, Unix/386 tries to gauge the size of a PC's memory. When it tried to read the first byte of the 17th megabyte, the All-star PC's memory subsystem refused to complete the memory-bus handshake and the system froze. A new address-decoder PLD cured that problem, and we loaded SCO's Open Desktop without further trouble.

OS/2 version 2.0 also didn't like the All-Star PC's configuration and refused to load. However, in this case the PC's hardware wasn't freezing; the processor continued to execute code, but externally, the PC was dead and wouldn't load OS/2 from the floppy. The same problem appeared when we tried to load

OS/2 version 2.0 on a Cheetah system using a genuine WD1003 disk controller, again exonerating the Hyperstore 1600. It was probably a bit of a reach to expect that this pre-release version of OS/2 would run on the All-Star PC's complicated configuration, but we made the attempt anyway. By then time had run out, so we took a fall-back position. OS/2 version 1.1 loaded without any problems.

High-end PCs based on Intel's 80386 µP family give you many operating-system alternatives. For today's PC software, such as the engineering packages to be discussed in Part 5, DOS is the clear operating system of choice. However, the advent of multitasking, virtual-operating systems such as Unix/386 and OS/2 version 2.0 will allow software developers to create more powerful, interrelated sets of application programs for PCs in the years ahead. **EDN**

References

1. Booth, Derrick, "We've run out of gas with DOS," *The HAL-PC User Journal*, January, 1990, pg 40.
2. Groff, James R and Paul N Weinberg, *Understanding UNIX, A Conceptual Guide, 2nd ed*, Que Corp, Carmel, IN, 1988.
3. Leibson, Steven H, "CP/M-86 Versus MS-DOS: A User's Perspective," *Microsystems*, November/December 1982, pg 34.
4. Robbins, Judd, *Essential OS/2*, Sybex, Alameda, CA, 1988.
5. Wright, Maury, "Graphics environments," *EDN*, October 26, 1989, pg 152.

Sculpture by Kathy Jeffers/Sculpture Photography by Chris Vincent. Photography by Steven Leibson unless otherwise noted.

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EDN's PC All-Stars **OS/2 Version 2.0**

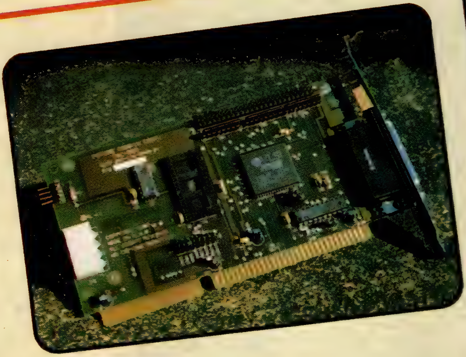
Microsoft Corp, Box 97017,
Redmond, WA 98073-9717.
(206) 882-8089.
Circle No. 655

BIO: OS/2 is the next step on DOS's evolutionary ladder. It offers multitasking and a standard graphical user interface. In addition, version 2.0 breaks away from the 80X86 family's segmented architecture and instead supports one large, linear memory model and virtual-memory operation.

STATS:
PROCESSOR: 80386 family
FILE SYSTEMS: DOS or high-performance file system
GRAPHICAL USER INTERFACE: Presentation Manager
RECOMMENDED RAM: 4M bytes min
GRAPHICS-CARD SUPPORT: CGA, EGA, VGA
NETWORK SERVICES: LAN manager (optional)

EDN's PC All-Stars **TMC-860 SCSI Host Adapter**

Future Domain Corp, 2801
McGaw Ave, Irvine, CA 92714.
(714) 253-0400.
Circle No. 656



STATS:
BUS: IBM PC/AT
PERIPHERAL INTERFACE: SCSI
MAXIMUM NUMBER OF PERIPHERALS SUPPORTED: 6
SCSI I/O CONNECTORS: 1 internal, 1 external
BIOS: DOS INT13 driver, can be disabled
ADDITIONAL DRIVERS: Sytos, Unix

BIO: The TMC-860 can control SCSI-based hard-disk drives in DOS and Unix environments and can also be used to operate SCSI-based tape and optical-disk drives.

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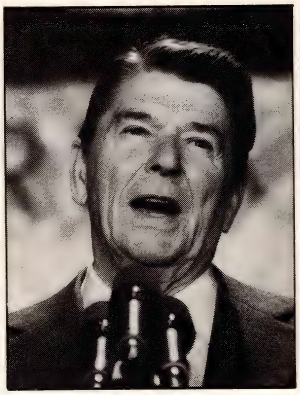

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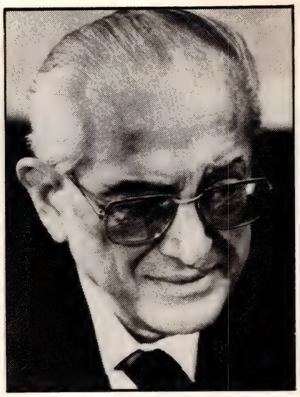

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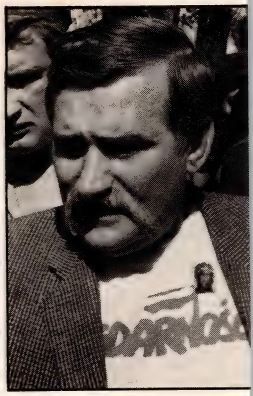

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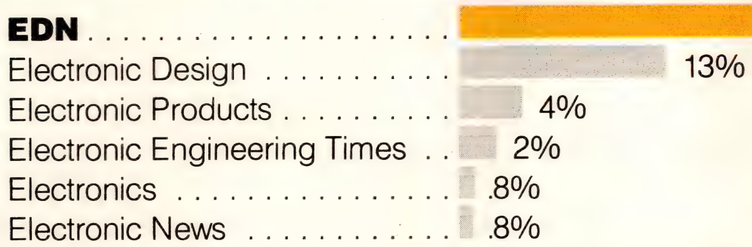

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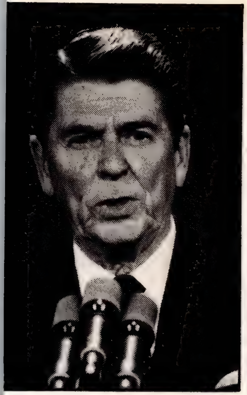

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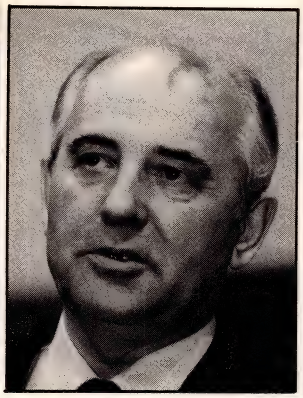

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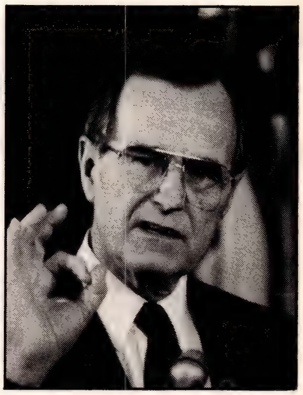

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Components News

FROM YOUR STRATEGIC PARTNER

Philips Components, Marketing Communications Dept.
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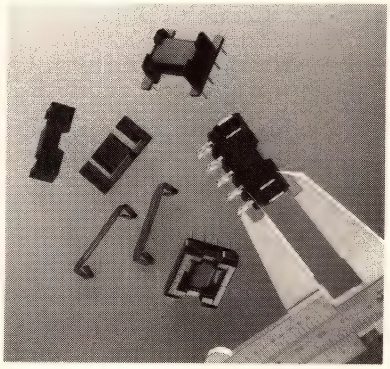
EFD cores reduce the size of power modules in telecoms and EDP

Taking advantage of its recently announced 3F3 low-loss ferrite material, Philips Components is introducing a range of flat E-cores which help reduce the height of transformers in DC-DC power modules and hence reduce the size of power modules for Telecommunications and EDP.

The new EFD (Economic Flat Design) transformer cores can be operated at up to 1 MHz, with throughput power densities as high as 20 W/cm³.



New EFD cores cut the size of telecoms and EDP power modules.

Optimized for 500 kHz operation, the EFD15/8/5 gives a total transformer height of 8 mm. The EFD20/10/7, optimized for 300 kHz, can be used to make transfomers that are just 10 mm high. The EFD25/13/9 and EFD30/15/9 are optimized for 100 kHz transformers that are only 12.5 mm high. The range is supplied with matching coil formers and clips suitable for automated production lines.

Circle 140

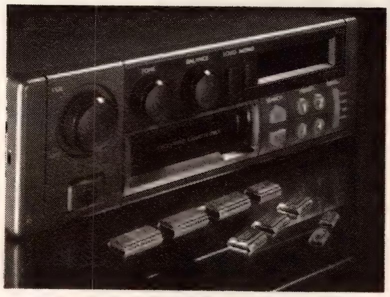
SMD tuner chip-set brings professional features to AM/FM radios

The TDA1072AT/TDA1572T and TDA1574T/TDA1596T/TDA1598T ICs from Philips Components form a complete hi-fi AM/FM tuner chipset for car and home radios and tuners. They are available either in DIL packages or in SO packages for surface mounting.

The TDA1072AT AM Receiver performs all the functions for AM reception. The TDA1572T AM Receiver is similar to the TDA1072AT but also has an amplitude controlled IF output for AM stereo operation or search tuning.

The remaining three ICs comprise the FM radio chip set which achieves high selectivity and good large-signal handling with very low levels of noise and harmonic distortion. It reaches noise-limited sensitivity with a signal-to-noise ratio of 26 dB with a 2.6 µV RF signal input. The signal-to-noise ratio with an RF signal input of 1 mV is better than 60 dB, harmonic distortion is less than 0.3% and AM suppression is better than 55 dB.

The TDA1574T Integrated FM Tuner performs all the FM front-end functions and also provides keyed AGC for a peripheral RF preamplifier. The TDA1596T FM Amplifier/Demodulator provides not only IF limiting and demodulation but also static and dynamic mute control of the audio signal. The TDA1598T Time-Division Multiplex Stereo Decoder is matched to the MPX output from the TDA1596T by an external resistor.



This chip-set from Philips Components performs all the functions for a complete hi-fi stereo AM/FM radio.

Circle 141

High-voltage diode has recovery time below 50 ns

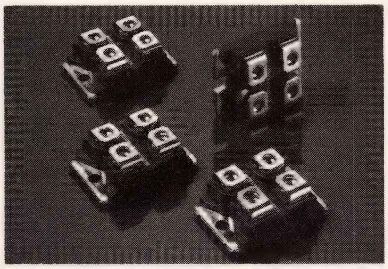
Philips Components is releasing a range of high-voltage double diodes in ISOTOP envelopes with maximum reverse recovery times ranging from 50 to 70 ns, dependent on type. The BYT230PI rectifiers feature a low forward voltage of just 1.8 V and aim at switched-mode power supplies and other high-frequency circuits, where low

PASSIVES ▫ LCDs ▫ SEMICONDUCTORS ▫ DISPLAY

Philips Components

conduction and switching losses are essential.

The glass-passivated high-efficiency rectifiers come in seven versions, with repetitive peak reverse voltages between 200 and 1000 V. Each double diode has an average forward current rating of 2x30 A.



The BYT230PI – in a rugged ISOTOP package – has a soft recovery time of 50 ns.

The ISOTOP package is available with fast-on or screw terminals. With a volume of just 6 cm^3, the package offers the highest power/volume ratio of any power semiconductor package on the market.

Circle 142

Audio amplifier provides high-quality playback in car cassette recorder

The TEA0655 from Philips Components is a bipolar integrated playback amplifier for stereo cassette recorders, and is designed to provide high-quality stereo sound in a car's harsh electrical and climatic environment. Dual channel signal processing enables optimum channel matching, and no preamplifier is required.

Each channel consists of a head amplifier, equalization amplifier with switched time constant, and a Dolby® B noise reduction circuit. The signal-to-noise ratio is typically 84 dB (CCIR ARM-weighted and Dolby B noise reduction enabled) with typical total distortion of 0.08% and stereo channel separation of 65 dB, at an input frequency of 1 kHz and 0 dB gain. The head and equalizer amplifier have a nominal gain of 30 ±1 dB with a maximum channel gain difference of ±0.5 dB.

The TEA0655 operates from a supply voltage of between 9.0 and 15.0 V within a temperature range of −40 to +85°C. With a supply voltage ripple of 250 mV, at 1 kHz, the IC supply voltage ripple rejection is 63 dB.

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The TEA0655 audio amplifier provides high-quality stereo sound in a harsh automotive environment.

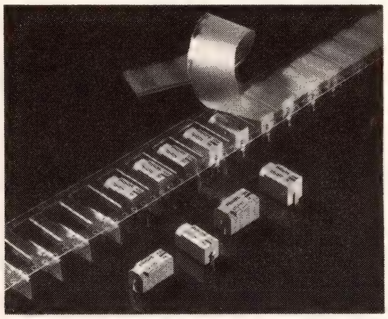
Circle 143

Surface mounted electrolytics double in capacitance

With its 2222 139 range, Philips Components has doubled the CV product of electrolytic capacitors available to surface-mount designers. The range consists of seventeen devices with capacitance values up to 220 µF (at 6.3 V), and voltage ratings up to 100 V – twice the previous values available on the market. These new non-solid aluminium electrolytics are rectangular (more suited to automatic placement than cylindrical types), and withstand all common soldering methods. They will allow more designs to be produced exclusively using surface mounting techniques, thus dramatically reducing production costs, and making it easier for Computer Integrated Manufacturing techniques to be introduced into equipment production.

The range gives a choice of 17 capacitance values, and 8 voltage ranges: from 220 µF at 6.3 V to 0.22 µF at 100 V. There are two case sizes with maximum dimensions of 14.5 by 7.05 by 6.3 mm (lxhxw) and 14.5 by 8.35 by 7.7 mm. The capacitors are suitable for filtering, smoothing, coupling and decoupling, timing and energy buffering in a variety of demanding industrial applications such as automotive, telecoms, data processing and control. Their rectangular shape allows precise automatic placement and small placement tolerances, with conducting tracks running below the component body.

Working between −55 and +105 °C, the capacitors have typical lifetimes of 2000 hours at 105 °C, rising to about 15 years at 40 °C. They are supplied in 24 mm blister tape.



These new SMD non-solid aluminium electrolytic capacitors from Philips Components have capacitance values of up to 220 µF at 100 V.

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CIRCLE NO. 116

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DESIGNER'S
GUIDE

precision dc
current sources
Part 1

Op amps turn voltage references into current sources

This 3-part series demonstrates the fine art of designing, analyzing, and trimming accurate, stable dc current sources. Part 1 begins with current-source basics and then analyzes several practical circuits, each of which requires only one op amp. Part 2, which also appears in this issue, describes 2-op-amp current sources, and part 3 will cover digitally controlled current sources.

Jerald Graeme, *Burr-Brown Corp*

Analog instrumentation and test systems use both voltage and current references. These circuits act as both dc standards and precision bias sources; as such, they form the basis for most electronic measurements. Of the two types, voltage references are more common and are available in great variety as integrated circuits. Far less variety is available in current references, so designers use op amps to adapt the more plentiful voltage-output devices to provide current. The resulting circuits supply currents from picoamperes to amperes. Some produce fixed currents; others supply currents that vary in response to analog signals. Still others permit digital control of their outputs.

Conceptually, you need only a resistor to convert a reference voltage to a reference current. Resistor conversion remains the basis for all voltage-to-current converters. However, to convert accurately, you must make the voltage across the conversion resistor insensitive to the load voltage. With just a voltage reference and resistor, as in **Fig 1a**, the load voltage introduces a large error. Op amps can prevent this error by isolating the load and reference voltages through one of three characteristics: open-loop gain; power-supply rejection; or, in circuits with more than one amplifier, common-mode rejection.

In the most common voltage-to-current converter, an op amp's gain provides conversion accuracy but restricts the ground return of the load. This circuit, shown in **Fig 1b**, removes the load ground connection and refers the load to the virtual ground of an op amp. The op amp's output supports the load voltage, V_L; the op amp's open-loop gain isolates the voltage-to-current conversion from the load voltage. The full reference voltage, V_R, appears across R_S because the op amp's input presents zero voltage to R_S. The resulting current through R_S is precisely $I_O = V_R/R_S$; feedback forces this current through the load. The circuit is commonly used for adding bipolar offset to current-based DACs.

The accuracy of I_O depends on component tolerances and the op amp's dc input errors and gain. The tolerances of V_R and R_S, each typically 1%, combine to produce a 2% error that you can remove by trimming

Conceptually, you need only a resistor to convert a voltage to a current, but to convert accurately, you must make the resistor voltage ignore the load voltage.

R_S. Trimming also removes the static errors caused by the op amp's offset voltage and input bias current. With the Burr-Brown OPA27, the op amp's offset alters the voltage on R_S by only 25 μV, or 10 ppm of the 2.5V supplied by V_R. A similar error results from the op amp's input bias current, which adds 40 nA, or 40 ppm, to the 1 mA shown. Trimming reduces the combination of these dc errors to the point where thermal drifts are the major error sources. Both V_R and R_S have TCs of about 0.005%/°C, so the total output drift is about 0.01%/°C. Drifts of the op amp's dc errors usually add little to the circuit drift. With a drift of 0.01%/°C, practical control of room temperatures limits the circuit's trimmed accuracy to approximately 0.05%.

The op amp's finite gain affects accuracy through the output resistance of the current source. In an ideal current source, this resistance is infinite; but in the circuit in **Fig 1b**, the op amp's gain-error signal permits the load voltage, V_L, to slightly change I_O. To support the load voltage, the op amp requires a gain-error signal of V_L/A between its inputs, where A is the open-loop gain. This op-amp input error reduces the voltage on R_S so that I_O changes by V_L/AR_S. The resulting output resistance, R_O, is V_L divided by the I_O change, so $R_O = AR_S$. With the OPA27 in **Fig 1b**, $R_O = 10^6 R_S$, a million-to-one improvement over the performance of the circuit in **Fig 1a**. With the components shown in **Fig 1b**, the output resistance is $2.49 \times 10^9 \Omega$, a value that produces a negligible error.

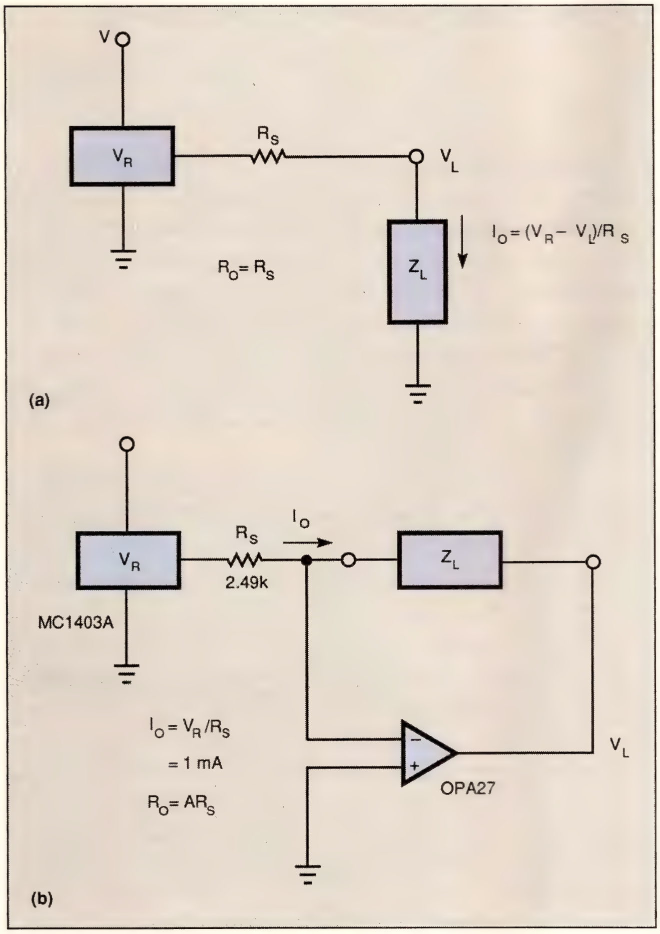

***Fig 1—The load-voltage error** of this elemental voltage-to-current converter, **a**, is usually removed by op-amp gain, **b**, but this solution does not permit a grounded load.*

Although this commonly used circuit produces an output current that is independent of the load, Z_L, the load-return path restricts the circuit's usefulness. You must return Z_L to the virtual ground of the op amp instead of to the more widely accessible system ground. Though acceptable for a committed application, such as bipolar offsetting in a DAC, this restriction is inconvenient and can produce frequency instability in more general applications. Including Z_L in the feedback path of the op amp affects frequency stability because Z_L is a primary determinant of the op amp's feedback factor.

Because current references must drive loads with widely varied impedances—in circuits like those in **Fig 1**—the op amp's feedback factor is uncertain, and oscillation can occur with many loads. Moreover, separation between the op amp and the load adds stray wiring capacitance to the op amp's inverting input and promotes oscillation. To overcome these shortcomings, the system ground acts as the load-return point in the following alternative voltage-to-current converters.

Float the reference, ground the load

Using only one op amp, you can form grounded-load current references by taking advantage of the op amp's power-supply rejection ratio (PSRR) to isolate the source and load voltages. These circuits place no restrictions on the load-return point; you can return the load to ground or to any fixed or varying voltage without substantially affecting the output current. Three such current references illustrate a wide range of current levels and compliance voltages.

Two of these references use the same basic configuration (**Ref 1**) but differ in output polarity. They demonstrate the basic circuit's extremes of output current and compliance. **Fig 2** shows the circuit as a current sink with a low-level output and nominal compliance. By bootstrapping a 2-terminal reference and its cur-

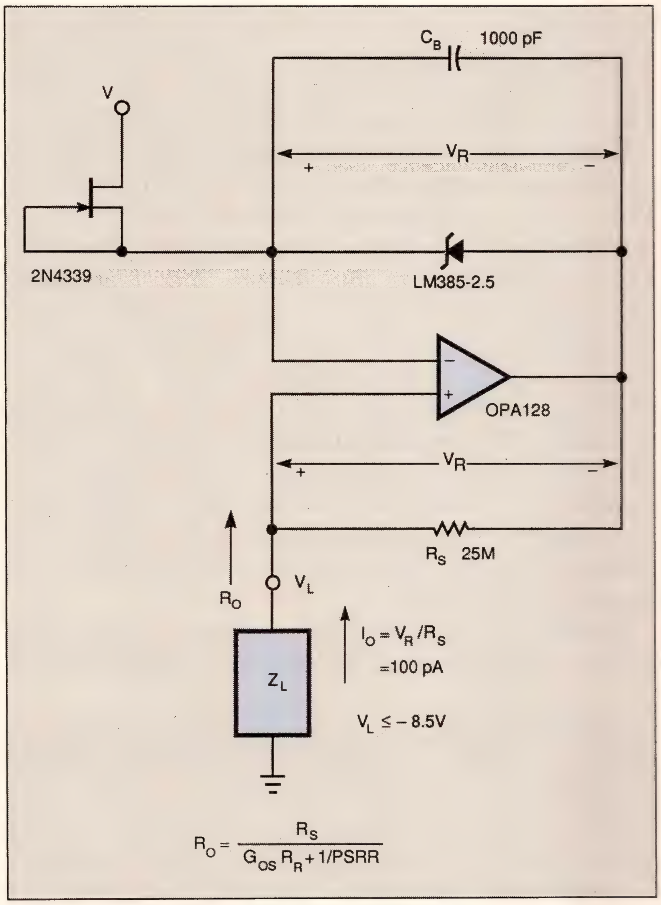

Fig 2—In this grounded-load, voltage-to-current converter, *a single op amp produces a 100-pA current sink by bootstrapping the reference on the load.*

rent-converting resistor to the load voltage, the circuit converts the reference's output to current. A biasing JFET current source helps establish the reference voltage, V_R, between the op amp's output and inverting input. By requiring the two op-amp inputs to be at the same voltage, feedback forces an equal voltage between the op amp's output and noninverting input, thereby impressing V_R across the current-sense resistor, R_S. Thus, regardless of the load voltage, feedback drives a stable current, $I_O = V_R/R_S$, through R_S and into the load.

The whole source floats on the load

Load-voltage changes merely shift the potential of the entire current-source circuit and leave I_O largely undisturbed. Op-amp feedback readjusts all circuit voltages to accommodate the load voltage while retaining the fixed input-to-output drop on the op amp. Three factors limit this readjustment and determine the output resistance of the current source. The output resistance of the JFET current source, the internal resistance of the voltage reference, and the power-supply sensitivity of the op amp all permit V_L to somewhat affect I_O. The load voltage across the JFET reacts with the device's output resistance, $1/G_{OS}$ (G_{OS} is the common-source output conductance of the JFET). This reaction affects the current the JFET supplies to the voltage reference, allowing both output voltage changes and the voltage reference's internal resistance, R_R, to affect V_R and, therefore, I_O.

Similar load-voltage sensitivity in the op amp affects I_O as expressed by the device's PSRR. The load voltage shifts the inputs and output of the op amp equally so that gain and CMRR do not cause additional errors. However, this shift alters voltages within the op amp just as if the positive and negative power-supply voltages had changed equally by V_L. This change produces a differential input error for the op amp as defined by the device's PSRR. This error, $V_L/PSRR$, appears between the op-amp inputs and causes a small voltage change across R_S.

Combined, the preceding three error sources in the circuit in **Fig 2** produce an output resistance of

$$R_O = R_S/[(G_{OS} \cdot R_R) + 1/PSRR].$$

For the specific components in **Fig 2**, $R_O \sim 25{,}000 \cdot R_S = 6.25 \times 10^{11} \Omega$. This output resistance is 25,000 times higher than that of **Fig 1a**'s elementary circuit. Although 25,000:1 is less than the improvement offered by **Fig 1b**'s circuit, the output resistance is still a negligible source of error.

Calculate effects of op-amp input errors

The effects of component tolerances and the dc input errors of the op amp are more significant sources of error. Usually, the tolerances and drifts of V_R and R_S dominate the error of a current reference. As described for **Fig 1b**, these tolerances and drifts impose a practical accuracy limit because they override the circuit's trim resolution. In the circuit in **Fig 2**, as in that of **Fig 1b**, these errors impose a 0.05% accuracy limit for general applications. However, for the very low currents generated by the circuit in **Fig 2**, two factors increase the error. First, the high value of R_S requires that you use a resistor with a 5% rather than a 1% tolerance and with a drift of 500 ppm/°C rather than 50 ppm/°C. As a result, R_S and V_R together introduce an initial

With only one op amp, you can form grounded-load current references by using the op amp's power-supply rejection ratio to isolate the source and load voltages.

error of 6% and a stable trimmed-accuracy limit of about 0.27%.

The second factor that increases error is the op amp's input bias current, I_B. In **Fig 1b**'s circuit, you can ignore the op amp's dc input errors; but if you make I_O very low, you must re-examine these errors. In the circuits in both **Fig 1b** and **Fig 2**, these errors change the output current to

$$I_O=[(V_R+V_{OS})/R_S]+I_B.$$

Generally, the offset voltage, V_{OS}, is much smaller than V_R and remains a minor error source, but I_B imposes a lower limit on I_O. The low output-current extreme is not set by I_B itself because trimming removes the initial errors. However, thermal drift in I_B disturbs the trimmed accuracy, just as the drifts of V_R and R_S do in more typical cases.

With an output current of just 100 pA, the circuit in **Fig 2** illustrates the low output-current extreme achievable with this basic circuit configuration. With an OPA128, the op amp input-current drift is only 30 fA over the 20-to-30°C temperature range. This drift is just 0.03% of the current reference's output. Added to the trim limit imposed by R_S and V_R, the I_B drift raises the final trim limit to 0.3%. However, retaining this accuracy requires great attention to parasitic leakage and noise. To avoid leakage, you should form the junction of R_S, Z_L, and the op amp on a Teflon standoff; to limit interference pickup, you should keep the wiring to the junction short. The simplicity of the circuit in **Fig 2** helps meet these requirements, since there are few components to pick up leakage and noise.

Although this circuit produces a dc output, you must pay attention to the ac characteristics of the voltage reference's feedback loop. For greatest accuracy, the voltage reference is not a simple zener diode but an analog reference circuit with a response pole of its own. Enclosing this response pole in the op-amp feedback places two poles in the loop. You must make one of the two poles dominant to retain frequency stability. Feedback-bypass capacitor C_B lets you easily stabilize the circuit. This capacitor bypasses the voltage reference and leaves the op amp in control of the loop at higher frequencies.

The power-supply voltage and the elements that compete with Z_L for this voltage determine the voltage compliance—the voltage range available to the load. The competing elements are voltage drops in the op amp's output circuit and the voltage across R_S. With the OPA128, internal voltage drops limit the op-amp output to 4V less than the power-supply level. Combining this voltage with the 2.5V across R_S yields 6.5V, which leaves an 8.5V compliance with 15V supplies.

Higher compliance voltages require a higher-voltage op amp such as the OPA445 in the circuit in **Fig 3**. This circuit also illustrates the high current extreme and the opposite polarity connection of the circuit in **Fig 2**. Switching from current sink to current source only requires reversing the connections of the voltage reference and the JFET. These changes invert the polarity of the current-setting voltage across R_S. Changing to a higher output current is simply a matter of reducing R_S until the op amp's output-current capability constrains I_O. The op-amp output supplies both I_O and the current drawn through the voltage reference. Setting the latter current low through your choice of the JFET leaves most of the 15-mA op-amp output available for I_O.

Raising the compliance limit requires higher-voltage power supplies and an op amp that accepts the in-

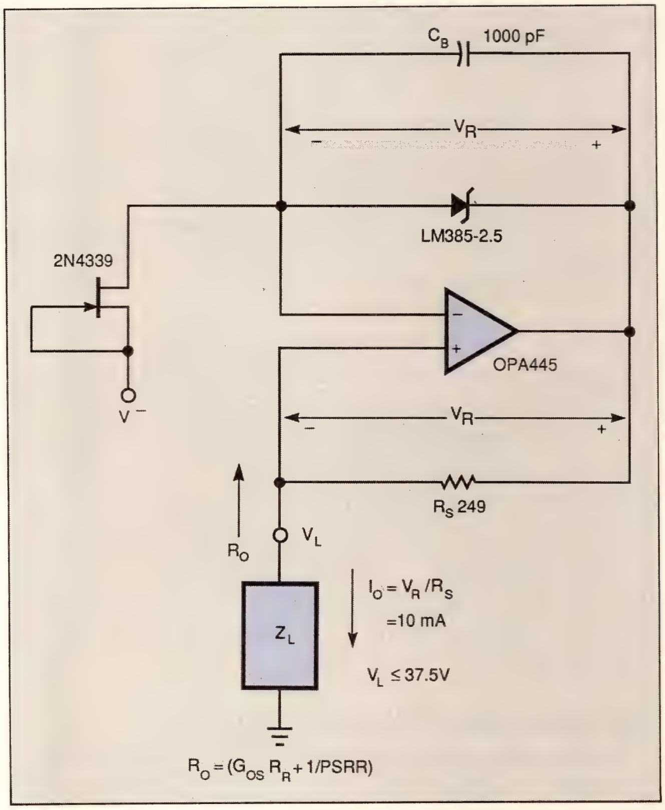

Fig 3—Altering the configuration *of the circuit in* ***Fig 2*** *reverses the current-source polarity and enables this circuit to supply larger currents and exhibit greater load-voltage compliance.*

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Switching from a current sink to a current source only requires reversing the connections of the voltage reference and the JFET.

creased voltage. However, the higher voltages do not increase the demand on the 2-terminal voltage reference, which, because of bootstrapping, sustains only its own voltage—not the increased load voltage. Three-terminal references lack this convenience, because you must connect them directly to one of the power supplies. Using the OPA445 high-voltage op amp in **Fig 3** increases the permissible power-supply level to ±45V and allows an op-amp output as great as ±40V. The 2.5V across R_S reduces this output level to yield a 37.5V load compliance.

Errors in the output of this circuit follow from those of the circuits in **Figs 1b** and **2**. With R_S again in the range that permits using precision resistors and with I_O much greater than I_B, the circuit has static errors similar to those of the circuit in **Fig 1b**. The tolerance and drifts of R_S and V_R predominate over the op amp's much smaller dc input errors. As in **Fig 1b**, these errors set the circuit's initial error at 2% and its final trimmed accuracy at 0.05%. Errors caused by output resistance follow from the analysis of **Fig 2**: $R_O = 25{,}000 \cdot R_S = 6.2\ M\Omega$. Again, this error is negligible.

Even higher output current with precise, variable control is the goal of the third single-op-amp circuit (**Fig 4**). Normally, this function would place high current demands on an op amp and a control potentiometer. To obtain high currents from the circuit in **Fig 3**, you would replace the op amp with a power op amp and substitute a high-current potentiometer for R_S. However, higher-power devices compromise accuracy. You can achieve better results by isolating the controlling circuits from the high currents. The circuit in **Fig 4** shifts the high currents to a voltage-regulator output and a fixed sense resistor. Voltage regulator V_R supplies the high-level output current through sense resistor R_S. A precision OPA27 and a low-current potentiometer, R_V, control the output current.

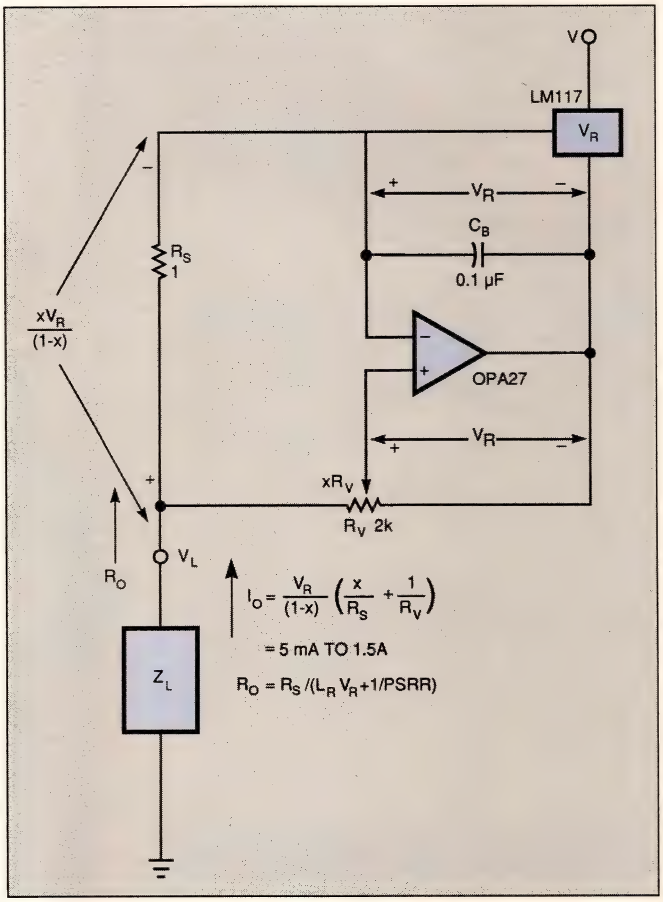


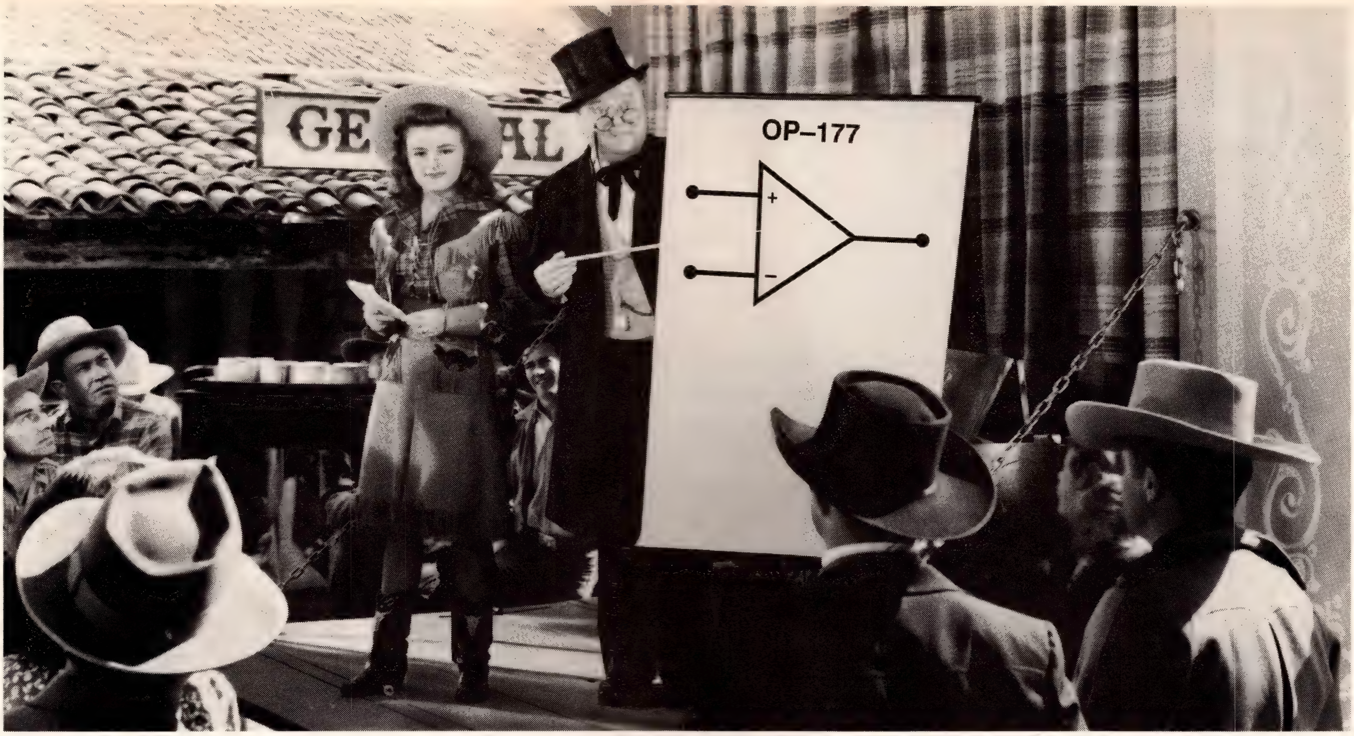
Fig 4—Precise, high-level reference currents *result from op-amp control of a voltage regulator and separation of the current-sensing and -control functions.*

The voltage-regulator output makes the op amp's input-to-output voltage equal to V_R, just as the voltage reference does in **Fig 2**. Feedback replicates V_R on the right-hand portion of R_V and fixes the potentiometer current. This current continues through the left side of R_V to develop a voltage on resistance xR_V, where x is the fraction of the potentiometer on the left side of the wiper. Feedback forces the voltage difference between the op amp's inputs to zero and reproduces xR_V's voltage on R_S. Thus, the fractional setting, x, of the low-current potentiometer, R_V, controls the voltage on the high-current sense resistor, R_S. Setting $x=0$ connects R_S directly across the op-amp inputs, where the voltage drop is zero. As x approaches unity, the voltage on R_S approaches infinity until current limiting in the regulator's output stage imposes a limit.

Between these potentiometer extremes, bootstrapping transforms the sense-resistor voltage into a load-insensitive output current. A voltage equal to that across Z_L appears at the regulator's return terminal and shifts the regulator's output voltage by an equal amount. This shift maintains both a constant voltage drop from the op amp's output to its inputs and zero voltage between the inputs. The op amp's bootstrap action forces the currents that flow in R_S and R_V into the load so that

$$I_O = [V_R/(1-x)](x/R_S + 1/R_V).$$

For the components in **Fig 4**, varying x sets I_O anywhere from 5 mA to 1.5A. Still, no more than 1.4 mA



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CIRCLE NO. 118

Parameter drifts with temperature impose a practical accuracy limit because they override the trim resolution.

flows from the op amp's output through the control potentiometer. The minimum and maximum output currents of the regulator set boundaries on the range of I_O.

Tolerance and op-amp errors similar to those of the circuit in **Fig 2** alter this behavior. The tolerances of V_R and R_S are 4% and 5%, respectively, and combine for a possible 9% initial error. The op amp's input errors produce an output-current error of $I_B + (V_{OS}/R_S)$, but this error is negligible for the higher currents of **Fig 4**. The OPA27 restricts this error to just 8 ppm of full scale. You can trim the combined effects of the above errors through a shunt adjustment of R_S or by adjusting the regulator. In practice, the TC of R_S limits the trim accuracy. Although the drift of V_R remains at the 0.005%/°C of previous circuits, R_S is a higher-power resistor with a typical TC of 0.015%/°C. The total thermal drift of this circuit is 0.02%/°C, so trimming can reliably yield 0.1% accuracy.

Line regulation gets into the act

The op amp's PSRR and the regulator's line regulation determine the output resistance of this current reference. As with the circuit in **Fig 2**, bootstrapping shifts both the inputs and the output of the op amp together so that V_L reacts with the op amp's PSRR. The resulting error between the op-amp inputs and across R_S is V_L/PSRR. Similarly, the output and return terminals of the voltage regulator shift by V_L, just as if the input voltage to the regulator had changed. The line regulation, LR, determines the regulator's response to this shift; V_R changes by $LR \cdot V_L$.

Together, the load-induced op-amp and regulator errors change I_O by $V_L(LR + 1/PSRR)/R_S$. Dividing V_L by this current change defines the output resistance as

$$R_O = R_S/(LR + 1/PSRR).$$

In most cases, line-regulation error dominates this expression. For the components shown, $R_O = 8000 \cdot R_S = 8\ k\Omega$. Although this resistance seems low, it remains orders of magnitude larger than the small load resistances this high-current reference drives. From this output resistance, the load sensitivity of I_O is $(Z_L/R_S) \cdot 125$ ppm.

In **Fig 4**, the separation of the current-sensing and -control functions reduces the circuit's output voltage compliance. Potentiometer R_V supports both the voltage across R_S and the reference voltage V_R. In **Fig 2**, these voltages merge to become the R_S voltage drop. In **Fig 4**, the two are in series, so both reduce compliance. As before, voltage drops in the op amp's output circuit add to the compliance reduction. The total restriction to compliance is the voltage on R_V plus the op amp's output voltage requirement.

To restore compliance, choose R_S, the voltage regulator, and the op amp for low voltage drops. Making R_S a low resistance limits its compliance reduction to 1.5V. The higher output voltages of most voltage regulators would greatly reduce compliance, but the 1.25V unit shown is actually an improvement over the voltage reference in **Fig 2**. Finally, the OPA27 functions normally until its output is within 2.5V of the power-supply voltage. Thus, with the components shown, the circuit permits load voltages to within 5.75V of the supply.

The next part of this designer's guide will show you how to use a few additional parts to remove some of the application constraints imposed by the circuits discussed here. **EDN**

Reference

1. Kaller, R, "With Input Bias Current of 40 fA, Op Amp IC Makes Low-Level Measurements," *Electronic Design*, May 15, 1986, pg 144.

Author's biography

Jerry Graeme is a prolific author on the subject of analog design. In addition to articles in EDN and competing periodicals, he has written several texts that many engineers consider to be the definitive works in the field. Jerry is the manager of instrumentation components design in the Analog Design Engineering Div of Burr-Brown Corp (Tucson, AZ). He has worked at Burr-Brown for 23 years. He holds a BSEE from the University of Arizona and an MSEE from Stanford University. His hobbies include photography, scuba diving, and woodworking.

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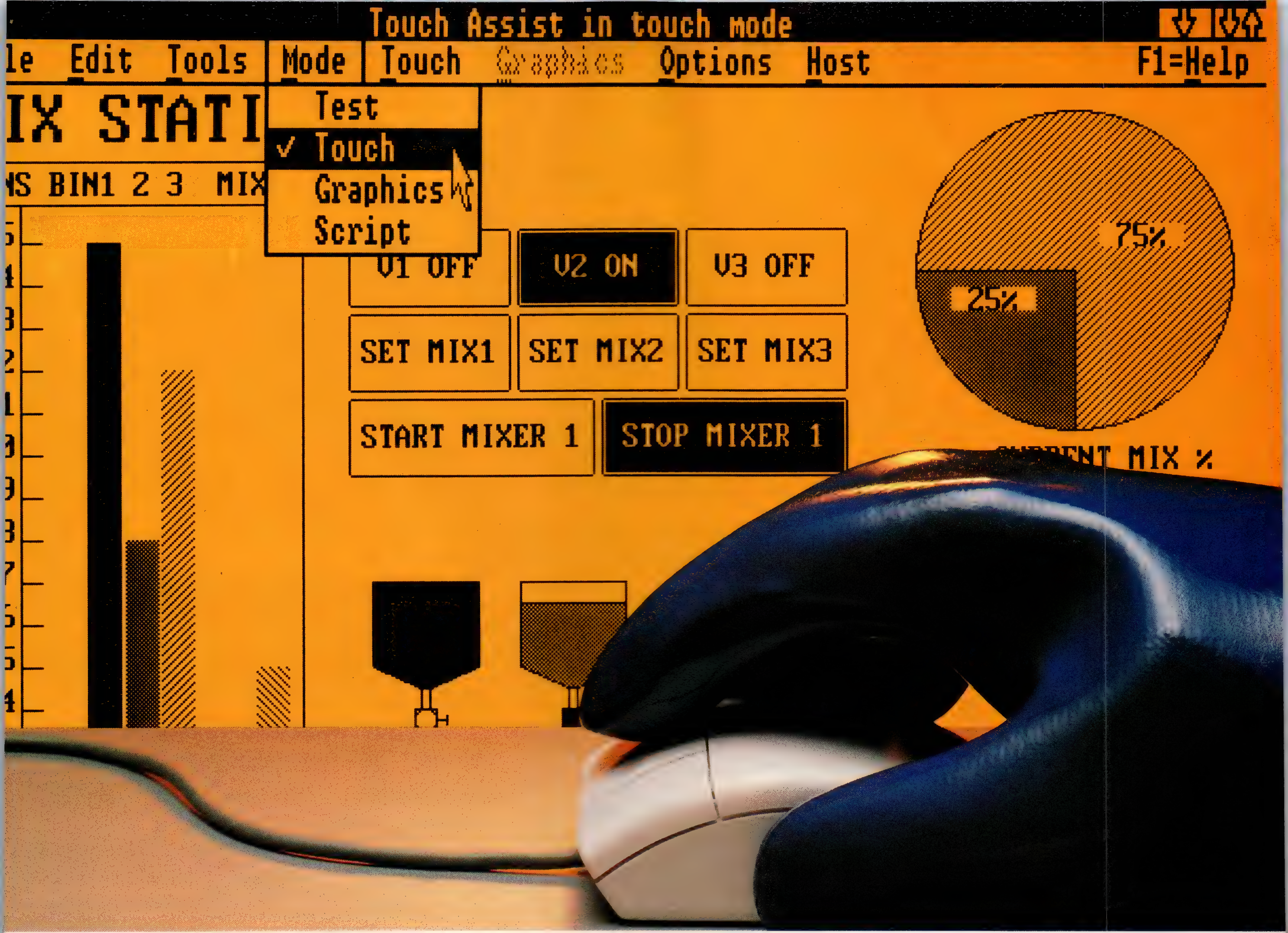

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CIRCLE NO. 122

DESIGNER'S GUIDE

precision dc current sources
Part 2

In current sources, two amplifiers can be better than one

As the first part of this 3-part series demonstrates, when you design an accurate current source you can do quite a bit with just one op amp. But when a current source must drive a ground-referenced load and share its voltage reference with other system components, a single amplifier usually can't do the job. This part discusses and analyzes circuits that use a pair of amplifiers. One of these circuits produces positive and negative current and lets you adjust the current through zero.

Jerald Graeme, *Burr-Brown Corp*

Single-op-amp current sources offer the conveniences of grounded loads and wide-ranging, variable outputs, but they do not permit bipolar control of the output current or the use of a grounded voltage reference. Adding a second amplifier removes these restrictions.

A single-op-amp, grounded-load current source achieves accuracy by driving, or bootstrapping, the voltage reference's return terminal. This restriction on the reference connection is acceptable when you can use a dedicated voltage reference as part of a current source. System applications, however, benefit from multiple uses of a single voltage reference: The signals derived from a single reference have initial errors and thermal drifts that tend to track those of the reference and, therefore, each other. Using the voltage reference for several purposes requires you to refer its output to the system common.

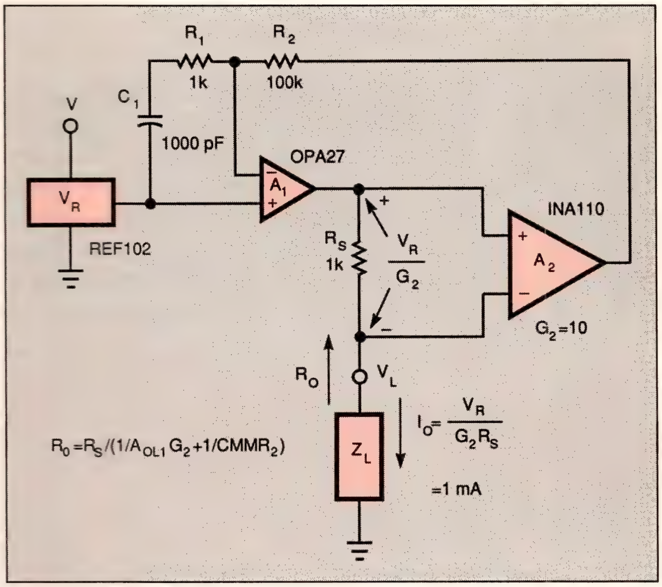

Fig 1—*An instrumentation amplifier's* *common-mode rejection ratio lets this current source drive a grounded load and derive its reference voltage from a grounded source.*

The current-reference circuit in **Fig 1** includes a grounded voltage reference and lets you ground the load. Because instrumentation amplifier A_2 amplifies the sense-resistor voltage, the circuit exhibits better compliance than do the circuits of Part 1 of this series. Replacing bootstrapping with differential feedback through A_2 lets you ground the voltage reference, V_R. The voltage that V_R presents to A_1 causes the op amp's output voltage to rise and the op amp to supply current to the load through current-sense resistor R_S. The cir-

By amplifying the current-sense resistor's voltage, you can often improve the voltage compliance because you reduce the IR drop in series with the load.

cuit does not take feedback from A_1's output because this voltage includes the load voltage.

The feedback does not depend on the load voltage, V_L; A_1 compares V_R only with the voltage across sense resistor R_S. Inserting instrumentation amplifier A_2 in A_1's feedback loop provides differential sensing of the voltage across R_S: A_2 rejects V_L as a common-mode voltage. At equilibrium, the feedback voltage delivered to A_1's inverting input equals V_R. This same voltage appears at the output of A_2 as there is no dc voltage drop across R_2. Capacitor C_1 blocks dc current from resistors R_1 and R_2; these elements only affect the circuit's ac performance for phase compensation. To develop V_R at the output of A_2, A_1 produces a voltage of V_R/G_2 between the instrumentation amplifier's inputs (G_2 is the gain of A_2). In so doing, A_1 drives a feedback-controlled current through R_S:

$$I_O = V_R/(G_2R_S).$$

Note that this expression contains an amplifier gain, G_2. The V_R/G_2 factor reflects the reduction in the voltage across R_S. The load compliance is better than that of circuits in which the full reference voltage is in series with the load. This characteristic is especially beneficial to system applications that use 10V references. When you use a reference such as the 10V REF102 in **Fig 1**, a dc voltage stable to 2.5 ppm/°C is available to the system and the voltage across R_S is only $V_R/G_2 = 1V$ (G_2 is 10). As with previous circuits, the compliance range must also allow for voltage drops in A_1's output. The common-mode range of A_2's input imposes a similar constraint. The more restrictive of the two amplifier limits determines this part of the compliance limit. With the amplifiers and voltage reference in **Fig 1**, the load voltage can rise to within 4V of the positive supply.

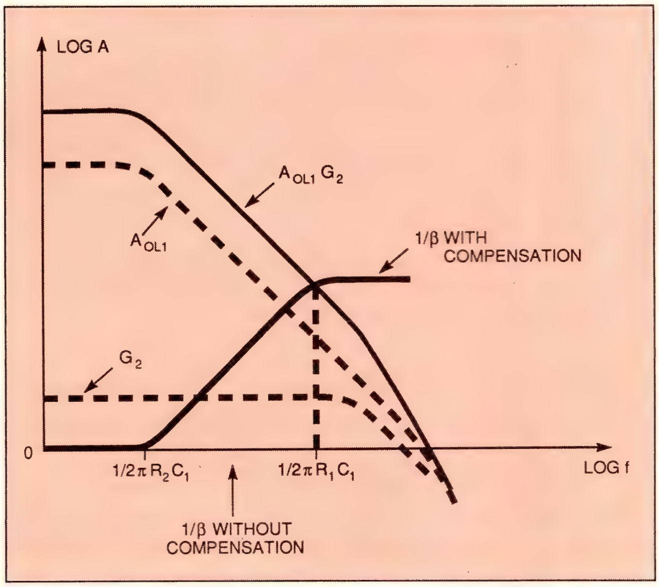

***Fig 2—Phase compensation of the 2-amplifier loop** in **Fig 1** requires moving the intercept of the 1/β and A_1G_2 curves to a region where the slope of the A_1G_2 curve is low.*

The output resistance is higher than that of circuits in which the load voltage affects the reference voltage. The load voltage only reacts with the open-loop gain of A_1, A_{OL1}, and the common-mode rejection ratio of A_2, $CMRR_2$. A_2's output supports the gain error signal between A_1's inputs. This gain error adds a voltage of $V_L/(A_{OL1}G_2)$ to the voltage across R_S. The common-mode error of A_2, which appears as $V_L/CMRR_2$ between A_2's inputs, also adds to the voltage across R_S. Together, the two error voltages produce an error current of $(V_L/R_S)[(1/A_{OL1}G_2)+(1/CMRR_2)]$. The output resistance, then, is

$$R_O = R_S/[(1/A_{OL1}G_2)+(1/CMRR_2)].$$

Note the appearance of G_2 in the denominator of this expression, which usually makes the gain error negligible. For the amplifiers shown, $CMRR_2$ sets R_O at 200,000 times R_S, or 200 MΩ. You can use even higher values of G_2 without reducing R_O. For a given output current, increasing G_2 reduces both R_S and the voltage across R_S. A lower R_S suggests a lower R_O, but with the INA110, $CMRR_2$ increases with gain and leaves R_O unchanged.

The compliance improvement afforded by a higher G_2 is, however, a compromise with the dc error. The input offset voltages of the two amplifiers reflect to R_S just as the gain and common-mode errors do. The result is an output error current of $[(V_{OS1}/G_2)+V_{OS2}]/R_S$, where V_{OS1} is the input offset voltage of A_1 and V_{OS2} is the input offset voltage of A_2. As G_2 increases and R_S decreases, the effect of V_{OS1} remains constant, but that of V_{OS2} increases. With $G_2 = 10$, the OPA27 and INA110 offsets produce a 0.025% error. Additional dc error results from the 1% tolerance of R_S and the 0.025% output error of REF102. Trimming R_S nulls the combined dc error to within the practical limit set by thermal drifts. With $G_2 = 10$, amplifier drifts are negligible, as is the drift of V_R. With the REF102, the drift of V_R is 2.5 ppm/°C rather than the 50 ppm/°C of the previous circuits. Only the 50 ppm/°C drift of R_S

remains significant. The practical, trimmed accuracy of the circuit is 0.025%.

Altering the high-frequency feedback through C_1, R_1, and R_2 assures the frequency stability of the 2-amplifier loop in **Fig 1**. Feedback analysis **(Ref 1)** demonstrates the need for the stabilizing elements and indicates the required component values. **Fig 2** shows the relevant gain and feedback curves. The individual amplifier gains, A_{OL1} and G_2, combine to form the loop's overall open-loop gain, $A_{OL1}G_2$. In practice, the voltage-divider action of R_S and Z_L reduces the composite gain from $A_{OL1}G_2$ and relaxes the circuit's stability requirements. However, to accommodate any possible Z_L, you must ignore this divider effect. When you do, the composite gain is the $A_{OL1}G_2$ curve in **Fig 2**, with each amplifier introducing a response pole prior to the unity-gain crossover.

To examine frequency stability, add the inverse of the feedback factor to **Fig 2**'s plot. For the circuit in **Fig 1**, the voltage divider formed by R_2 and the series connection of R_1 and C_1 determines the feedback factor, β. The inverse of the voltage-division fraction is $1/\beta \approx (1+R_2C_1s)/(1+R_1C_1s)$, for $R_2 >> R_1$. (The operator s equals $j\omega$.) At low frequencies, $1/\beta = 1$, and its curve follows the unity-gain axis in **Fig 2**. Without the compensation of the feedback divider, the $1/\beta$ curve would continue along this axis and intercept the $A_{OL1}G_2$ curve. This intercept would occur at the unity-gain crossover of the $A_{OL1}G_2$ curve—a curve that has a 2-pole roll-off. The difference in the slopes of the two curves, or the rate of closure, would be −40 dB/decade. This rate of closure corresponds to 180° of loop phase shift at the intercept and indicates oscillation.

The feedback divider prevents oscillation by moving the intercept of the two curves to a higher gain, where the slope of $A_{OL1}G_2$ is lower. A response zero causes the $1/\beta$ curve to rise at the break frequency of R_2 and C_1. The curve then heads toward a section of the $A_{OL1}G_2$ curve that has a slope of only −20 dB/decade. The slope of $1/\beta$ would still make the rate of closure 40 dB/decade, but the pole in the $1/\beta$ expression prevents this condition. The pole levels off the $1/\beta$ curve beginning at the break frequency of R_1 and C_1.

A 45° phase margin ensures stability

To ensure loop stability, choose the feedback-divider elements for 45° of phase margin. Using the Bode phase approximation **(Ref 1)**, you can read the loop phase shift from the slopes of the two curves near their intercept. Placing the intercept a decade in frequency below the second pole of the $A_{OL1}G_2$ curve removes the phase effects of the second pole. Then, the loop phase shift is the 90° of the first $A_{OL1}G_2$ pole plus the phase shift of $1/\beta$. Setting the $1/\beta$ pole at the intercept adds 45° of loop phase shift at the intercept for a net 135° phase shift and 45° of phase margin.

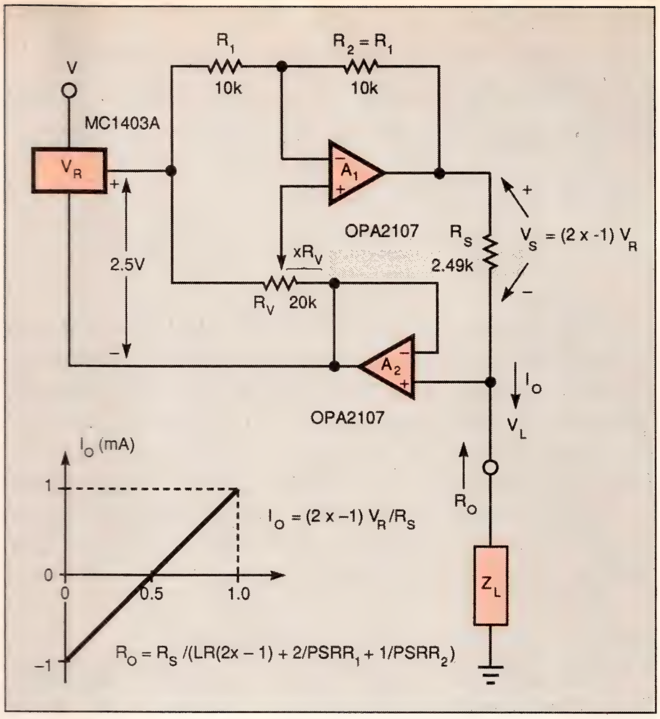

Fig 3—A variable output current *that spans both polarities results from adjusting the balance of positive and negative amplifier gains.*

Once you select the pole location for the $1/\beta$ curve, you'll know the relative values of the feedback elements. The pole frequency defines the R_1C_1 product, and the gain at which the pole occurs fixes $1+R_2/R_1$. Therefore, choosing one component defines the other two. Usually, you'll choose R_2 first because its resistance multiplied by A_1's input bias current produces a dc error.

Note that in **Fig 1** the feedback divider does not return to common. Instead, it returns to A_1's noninverting input. Either connection produces the same feedback factor and frequency-stability conditions for A_1. However, returning C_1 to common impresses the output noise of V_R across C_1 and R_1. The increased gain of the feedback divider would then amplify this noise. The return in **Fig 1** bootstraps C_1 and R_1 on the output of V_R and multiplies the noise of the reference by a gain of 1.

Each of the preceding current references lends itself to variable output but of just one polarity. To reverse the current polarity, you would have to change the voltage reference to one of the opposite polarity. Although this change is feasible, it is far less convenient than continuous current control spanning both the positive and negative ranges. By varying the amplifier gain with a potentiometer and using an ungrounded, dedicated voltage reference, the current reference in **Fig 3** provides such control **(Ref 2)**.

The compliance improvement afforded by higher feedback gain is a compromise; amplifier input-offset voltages affect the accuracy of current sensing.

Bootstrapping once again isolates the reference and load circuits but this time uses a separate op amp, A_2. This op amp feeds back load voltage V_L to drive voltage reference V_R and amplifier A_1. For both V_R and A_1, A_2 drives what would normally be the ground returns. You could connect these returns directly to the top of Z_L for bootstrapping, but each return would add current to the load. Instead, A_2 absorbs the currents and simplifies control of the load current.

For analysis, strip out the bootstrapping

To visualize the current control, separate the basic circuit from its bootstrap signal. The bootstrap drive of A_2 makes V_R and A_1 independent of the load voltage, so you can examine the circuit's operation for any value of V_L or Z_L. First consider the case of $Z_L=0$. The voltage on Z_L is zero, just as if the inputs and output of A_2 were grounded. With these virtual ground points, the circuit is simply a voltage amplifier connected to reference V_R and driving a load, R_S. In this simplified case, you can easily find the output current, I_O. It equals the current through R_S.

A variable balance of positive and negative gain controls the magnitude and polarity I_O. Connecting A_1 to the voltage reference as both an inverting and noninverting amplifier **(Ref 3)** develops the gain balance. The inverting connection has equal feedback resistors, R_1 and R_2, for a gain of -1. Adding to this gain is the gain of the noninverting connection, which varies according to the attenuation of potentiometer R_V. The portion of R_V between A_1 and A_2, x, controls this attenuation.

Varying x adds a varying amount of noninverting gain, which reduces the effect of the inverting gain. To demonstrate the gain combination, consider three key values of x. First, in **Fig 3**, with $x=0$, the noninverting input of A_1 connects directly to the output of A_2. This connection grounds A_1's noninverting input, as in **Fig 4a**, and adds no positive gain. In **Fig 4**, dashed ground symbols represent the virtual grounds that bootstrapping produces when $Z_L=0$. The net gain acting on V_R in **Fig 4a** is the -1 of the inverting connection. This net gain develops $-V_R$ across sense resistor R_S, for an output current of -1 mA.

With x at 0.5, the two sides of the potentiometer have equal resistances, thus producing the equivalent circuit in **Fig 4b**. Here, the equal-value resistors surrounding A_1 put the op amp in the difference-amplifier configuration. This difference amplifier has its inputs shorted together at the voltage reference's output. With no input-difference signal, **Fig 4b**'s circuit delivers zero output—the inverting and noninverting gains have equal magnitudes and their effects cancel so that $I_O=0$.

When $x=1$, **Fig 4c** applies. Then, V_R connects directly to the noninverting input of A_1. This connection places the op-amp inputs directly across R_1, yielding zero voltage across this resistor. With no voltage drop, R_1 supplies no current to R_2, so R_2 also has zero voltage. Zero voltage drop across R_2 means that A_1 acts as a voltage follower and transmits only the voltage at its noninverting input. From the follower action, the voltage developed across R_S is V_R, so the output

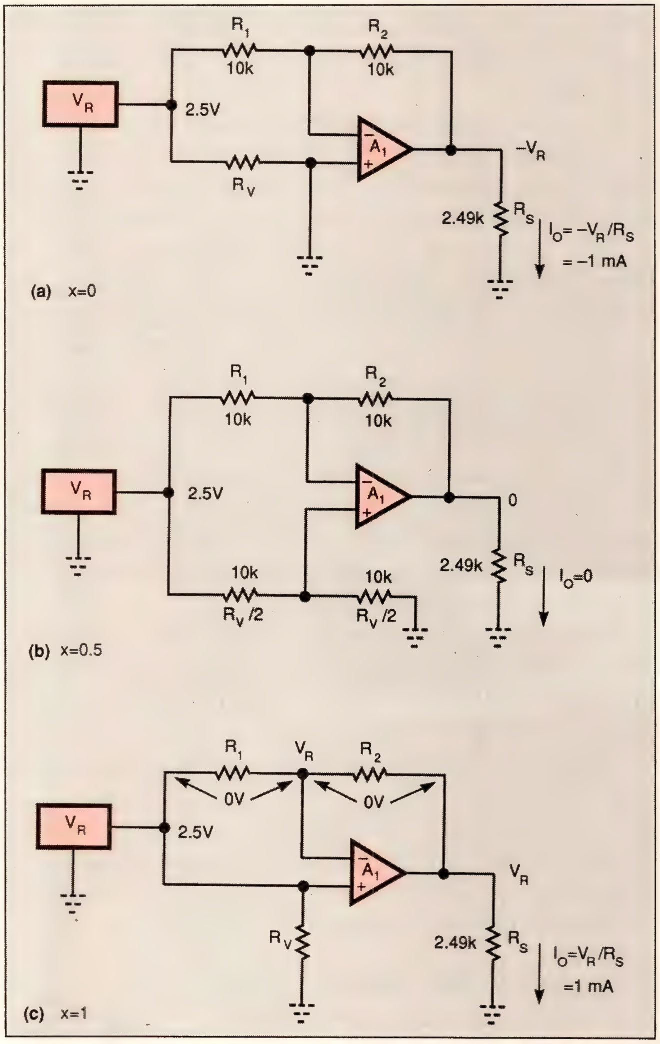

Fig 4—Continuous bipolar control *in the circuit of* ***Fig 3*** *results from using the potentiometer to vary the control-amplifier configuration from an inverter,* ***a****, through a difference amplifier,* ***b****, to a voltage follower,* ***c****.*

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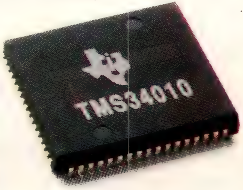

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To stabilize the current source for any possible load, you must ignore the effects of the voltage divider that includes the load resistance.

is 1 mA with the components shown. Between the settings in **Fig 4**, the output current varies linearly with x as described by

$$I_O = (2x - 1)V_R/R_S.$$

In practice, I_O behaves as this expression indicates, within accuracy limits set by the potentiometer, resistors, voltage reference, and amplifiers. The accuracy of the potentiometer dominates the control linearity and resolution expressed through x. With basic multiturn potentiometers, errors are in the 1% range; precision potentiometers reduce this error to approximately 0.1%. The tolerances and temperature coefficients of the fixed resistors mostly affect the circuit's gain error. Using 1% metal-film resistors with the 1% reference in **Fig 3**, the worst-case tolerance is 4%. You can trim this error by inserting a 500Ω potentiometer between R_1 and R_2 with the wiper making the connection to A_1's input. The 50-ppm/°C drifts of the three fixed resistors set the reference's temperature stability of gain. Total drift can be 0.02%/°C, which allows a trimmed accuracy limit of 0.1%. The potentiometer's tolerance and drift could affect the gain error, but the two segments of the potentiometer and their drifts match closely.

Amplifier and reference limitations define the circuit's offset, output resistance, and compliance. The op amps' input errors control the offset and output resistance. A_1 transmits its input error voltage to R_S; R_1 and R_2 establish a gain of 2. Similar errors from A_2 reflect directly to R_S through feedback control. Together, the input offset voltages of the OPA2107 dual amplifier produce an offset error of approximately 0.3 mV, or 0.12% of full scale. When you use offset-trimmable op amps such as the OPA602, a single-amplifier equivalent of the OPA2107, trimming can reduce the offset error to 0.01% of full scale.

Like the offsets, load-voltage-induced changes of the op amps' differential-input voltages also affect R_S. As described for the first grounded-load, single-op-amp voltage-to-current converter in Part 1 of this series, the amplifiers' power-supply rejection ratios (PSRRs) let you determine these input changes. The load voltage also affects the reference voltage, as described for the high-current circuit in Part 1. These amplifier and voltage-reference sensitivities combine to determine the current source's output resistance. The amplifier input errors transfer to R_S in the same way the offset voltages and line regulation (LR) directly affect V_R. These effects set the output resistance at

$$R_O = R_S/[LR(2x - 1) + 2/PSRR_1 + 1/PSRR_2].$$

With PSRRs of around 100,000 and an LR of 50 μV/V, the components in **Fig 3** develop an output resistance of $12{,}500 \times R_S$, or 31 MΩ. With this resistance, varying the output current over its full range produces an associated error of only 0.065% of full scale.

Compliance limitations in **Fig 3**'s circuit vary with the potentiometer setting, x, and are the most restrictive when $x = 1$. Then, voltage V_S, which is in series with the load, is at its maximum value, V_R. Although A_1 has internal voltage requirements of its own, its output must support V_R. Moreover, when $x = 1$, the full magnitude of V_R appears at the noninverting input of A_1 and places the greatest demand on the amplifier's input voltage range. So, at this potentiometer setting both the input and output voltage ranges of A_1 are taxed almost fully. The smaller of the two ranges, together with voltage V_R, determines the final compliance limits. For the 2.5V reference and the OPA2107 amplifiers, the circuit behaves normally until its output voltage is within 6.5V of the power-supply rails.

Thus the discussion of manually adjustable current sources concludes. The final part of this designer's guide will describe how to create digitally controlled current sources, which can be a little more complex than you might suspect.

References

1. Graeme, J, "Designer's guide to op-amp feedback circuits—Part 1," *EDN*, January 19, 1989, pg 131.
2. Graeme, J, "Bipolar Source Uses Unipolar Reference," *Electronic Design*, March 9, 1989, pg 83.
3. Graeme, J, *Designing with Operational Amplifiers: Applications Alternatives*, McGraw-Hill, New York, NY, 1977.

Author's biography

For Jerald Graeme's biography, see Part 1 of this series on pg 198.

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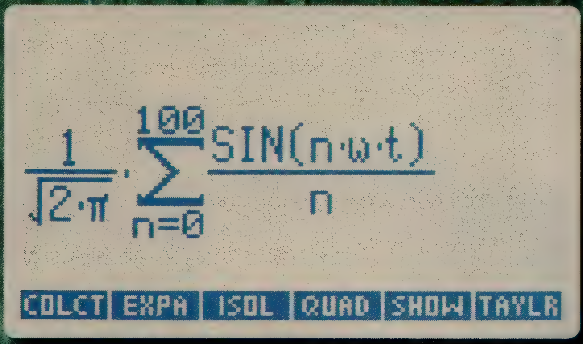

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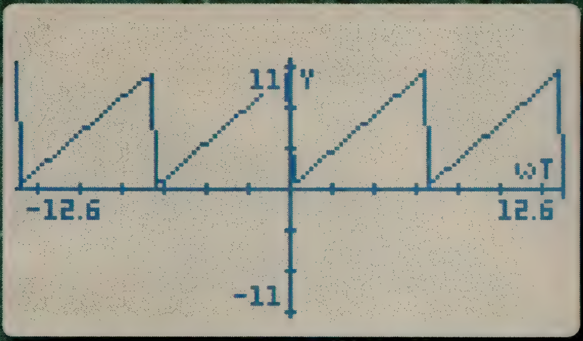

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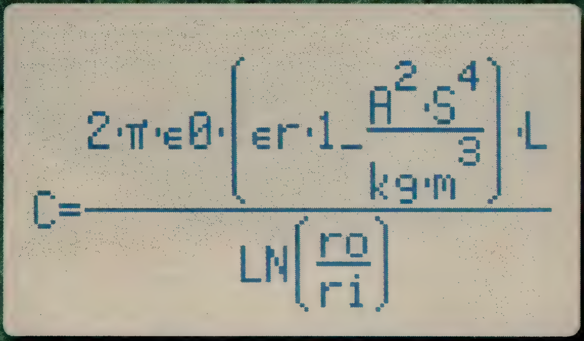

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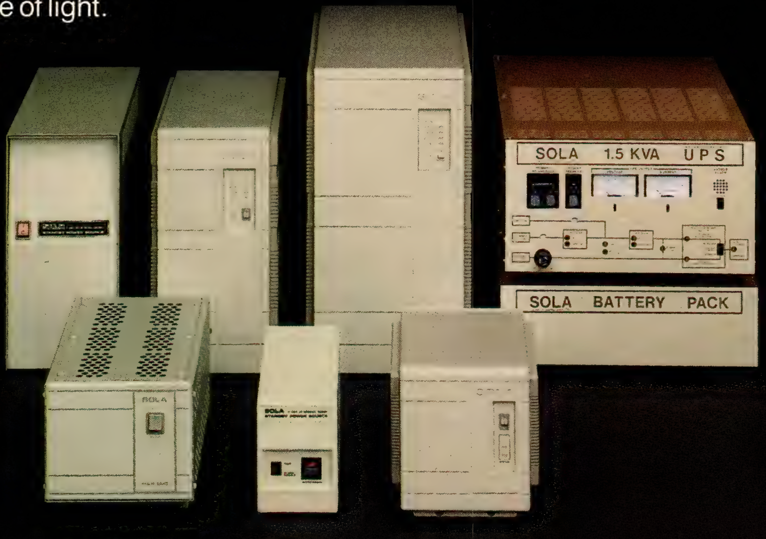


C function pointers let you build generic control systems

Many control programs are similar to each other, yet different enough that you can't just cut and paste older programs to accomplish new tasks. The C language, however, has features that help you design a general-purpose program that you can selectively compile for different applications.

Rick Brown, *Desert Research Institute, University of Nevada*

If you've ever designed software for embedded processors or control computers, you know that you often wind up doing the same or similar tasks over and over again. And, as your software skills develop, you'll often see new and better ways of accomplishing tasks that have already been completed. Wouldn't it be beneficial if you could easily work those better methods into your older projects? Well, the C programming language has features that allow you to do just that. C lets you create "general-purpose control programs," which aren't specific to any particular application. Rather, they provide a "bank" of modular, tested solutions to common problems, from which you can selectively compile the routines you need. Such modular code is adaptable to many control problems and makes revising older code easy.

The particular features of C that can help you write a general-purpose system include preprocessor *#if* statements, *#include* files, and the function pointer. Most programmers are familiar with the first two features—and know that the code can become almost incomprehensible when you try to make a single block of code do too many tasks. You can avoid that trap by judicious use of the function pointer, which provides a means of writing a very simple, yet versatile, general-purpose control program. As an example, you'll see how you can use the function pointer to create a general-purpose command decoder and program-monitor loop.

You can think of the function pointer as a type of "computed *goto*" command. It is, in its elemental form, simply a transfer-of-control address that you can manipulate as if it were a program variable. The two C code sequences in **Listings 1** and **2** accomplish the same task. Specifically, they transfer control to the function *george*.

More usefully, you can declare function pointers as arrays and as parts of structures. Further, you can organize an array of function pointers as a *stack*, in such a way that a new entry goes onto the top of the stack—that is, the array location with the lowest index. When you remove an entry from the stack, all entries with higher indices drop down to fill the void. A *stack of function pointers* allows a program that does not know what is on the stack to determine the control flow.

A function pointer is, very simply, a transfer-of-control address that you can manipulate as if it were a variable.

Listing 3 is an example of such a program. The *for* loop transfers control, in turn, to each of the functions to which the elements of the array *go*[*i*].*func* point. The code passes the integer *go*[*i*].*parm* to the routine, which then passes the parameter back again to be replaced in the structure. If the returned parameter value is zero, then the program executes the function *go_unstack()*, which removes the entry indexed by *i* from the stack. The code in **Listing 3** is the heart of a stack-of-function-pointers, general-purpose monitor loop.

Listing 1—Transfer of control by calling a function

```
int   george();           /*declare a function*/
...
@I{other code}
...
george();                 /*go to george*/
```

If you think that a lot of code has been glossed over as "other code," you're right—but the rest of this article will fill in some of those missing details. You'll see that you can think of that "other code" quite separately from the heart of the loop, and organize it into a family of code that will support many applications.

Description of the monitor

Before you can understand the application-specific code, you'll need to consider the monitor portion in some detail. **Listing 4** presents the salient monitor-code segments. The *#include* statement at line 1 brings in a *defs.h* file that you have edited to select the application being compiled. **Listing 5** shows the contents of that and other supplemental files. The *defs.h* file first selects the application you want to compile, by means of *#define* statements, and then selectively includes an appropriate *app_.def* file that contains all the switches, array sizes, and hardware addresses for that application.

For example, the size of the stack (defined by GO_SIZE) may differ between applications. Thus, you'd have to define it explicitly in each *app_.def* file. An additional function of the *defs.h* file is to define as FALSE all compilation-control switches that you have not explicitly defined in the *app_.def* file.

Listing 2—Transfer of control by using a function pointer

```
int   george();           /*declare a function*/
int   (*mary)();          /*declare a function pointer*/
...
@I{other code}
...
mary=george;              /*set mary to point to george*/
(*mary)();                /*go to george*/
```

Going back to **Listing 4**, lines 3 through 10 declare global variables that are common to all applications; lines 13 and 14 declare items located in assembly-language-code segments and ROM. The *main()* statement at line 17 is the program entry point. Lines 21 through 27 let you selectively include *app_.set* files, which contain executable code that initializes each application. The monitor-control loop, which begins at line 31, performs system-housekeeping tasks common to all applications. Such tasks may include timekeeping and the detection of operator or control input. The code sample assumes that the monitor-housekeeping code, together with assembly-language interrupt-processing code (not shown), will place characters entered by an operator into an input buffer (*operator_input*[]); will call the monitor command decoder whenever the operator enters a new-line key sequence; will increment the global variable *new_second* once per second; and will place digitized sensor values into the buffer *a_to_d*[]. That buffer is defined in an A/D-converter service routine (not shown); an entry in the *exte.h* file (**Listing 5**) declares this buffer as external to all other routines.

If your system needs to run on several different

Listing 3—Essentials of a stack-of-function-pointers monitor loop

```
struct {int   (*func)();          /*declare a function pointer    */
        int   parm;               /*and associated parameter      */
       } go[GO_SIZE];             /*this is a structure array
                                  of declared size GO_SIZE        */
int    go_sptr;                   /*index for go[].               */

{
int    i, x;                      /*temporary variables           */
...
other code
...
for(i=0; i<go_sptr; i++)
 {x=go[i].parm=(*go[i].func)(go[i].parm);
  if( !x ) go_unstack( &i );}
}
```

types of computers, then you may selectively include code that is specific to each computer type, as shown in lines 33 through 39. After performing the housekeeping tasks, the monitor will transfer control to any routines that those tasks have placed on the execution stack.

The monitor can place routines on the execution stacks as the result of operator action, the occurrence of external events, or expiration of a time interval. The remainder of **Listing 4** describes an operator-driven system in which entry of a command causes a sequence of events to occur. The monitor-command decoder, beginning at line 51, is an example of how a routine that knows nothing about its input or output can use function pointers to effect a transfer of control.

The code in lines 56 through 65 first compares a string entered by an operator to each string in a "command array," which contains all valid commands. Associated with each command string is a pointer to the function that the string represents. This command array may be ROM-resident, or it can be built by code in RAM, as shown at line 12 of **Listing 6**. When the monitor detects a match, it transfers control to the function pointed to by the command array and passes to the function, as a parameter, a pointer to the next character in the command string. The two routines shown in lines 69 through 77 and 79 through 90 (**Listing 4**) maintain the function-pointer stack.

Listing 4—Monitor-code segments

```
 1      #include "defs.h"       /*define the application        */
 2
 3      struct {int  (*func)(); /*control transfer stack.       */
 4              int  parm;
 5             } go[GO_SIZE];
 6      char go_sptr;   /*go stack index        */
 7
 8      struct {int  (*func)(); /*operator control transfer stack*/
 9              char  *cmnd;            /*pointer to command text       */
10             } command[NBR_CMDS];
11
12      /*        interrupt placed and ROM operands                     */
13      extern char operator_input[];   /*operator input command buffer */
14      extern char new_second;         /*time flag set by interrupt    */
15
16      /*              begin executable code                           */
17      main()
18      {
19      int  i, x;
20              /* System initialization code   */
21      #if APP1                                /*application 1         */
22      #include "app1.set"
23      #endif
24
25      #if APP2                                /*application 2         */
26      #include "app2.set"
27      #endif
28
29      /*              monitor loop                                   */
30
31      do
32      {
33      #if PC                          /*house keeping code for        */
34      #include "pc.c"                 /*PC type computers             */
35      #endif
36
37      #if Z80
38      #include "z80.c"                /*Z80 processor                 */
39      #endif
40
41      for( i=0; i<go_sptr; i++)       /*check the control stack       */
42           {x=go[i].parm=(*go[i].func)(go[i].parm);
43            if( !x ) go_unstack( &i );}
44
45        if( new_second ) new_second--;
46      }
47      while( 1 );
48      }

49      /*              support code                                   */
50      /*              routine to detect operator entered commands    */
51      cmd_deco()
52      {
53      char *cp1, *cp2;
54      int  i;
55
56      for( i=0; i<NBR_CMDS; i++)      /*determine if command entered  */
57       {cp1=operator_input;           /*command input buffer          */
58        cp2=command[i].cmnd;          /*possible command string       */
59        do                            /*test for command input        */
60         {if( *(cp1++) != *(cp2++) ) break; /*not this command        */
61          if( !*cp2 )                 /*EOS..have a command           */
62           {(*command[i].func)( cp1 );  /*go to process               */
63            i=999;                    /*abort 'for' loop              */
64            break;}}
65        while( *cp1 );}       /*until EO input S or command det       */
66      }
67      /*        routines to stack and unstack function pointers       */
68
69      push_go( func, parm )   /*routine to place a function           */
70      int  (*func)(), parm;   /*on the control stack                  */
71      {
72
73      if( go_sptr == GO_SIZE ) <process stack overflow error>
74      else
75       {go[go_sptr].func=func;        /*place new entry               */
76        go[go_sptr++].parm=parm;}     /*and parameter on stack        */
77      }
78
79      go_unstack( i )         /*routine to remove a function          */
80      int *i;                 /*from the control stack                */
81      {
82      int j, k;
83
84      k=*i;           /*index of function to remove                   */
85      for( j=k; j<go_sptr; j++, k++ )
86       {go[k].func=go[j].func;        /*squeeze function out of stack */
87        go[k].parm=go[j].parm;}
88      go_sptr--;                      /*reduce stack size             */
89      (*i)--;                         /*reduce index of callers loop  */
90      }
91
```

How to use the monitor

Listing 6 illustrates how you might develop an application that uses the monitor code to control its operation. This hypothetical application maintains the relative humidity of a test chamber at an operator-

A stack-of-function-pointers monitor is not appropriate for fast systems in which the time overhead for stack examination would be significant.

entered setpoint (or cycles it through a profile of setpoints). This application illustrates the activation of a function by an external event (operator input), the use of global variables to communicate with active functions, and the use of the parameter passed from the activation stack. All line references are to **Listing 6**.

The operator starts the humidity-control sequence by entering the command *HUMIDITY,S,nn*, where *nn* is the humidity setpoint, or *HUMIDITY,P,t,s1,s2,...,sn*, where *s1* through *sn* are set points for a humidity profile and *t* is the time in seconds to dwell at each setpoint. Humidity control ends on completion of a profile or when the operator enters the command *HUMIDITY,!*.

The *defs.h* file included at line 1 is the same file that was included in the monitor code discussed above. The *exte.h* file included at line 2 declares, as external, all identifiers that have been defined in the monitor, assembly code, and ROM segments. Lines 4 through 7 declare global identifiers that are specific to this application. At line 10 is the *humd_set()* function, which the monitor calls by means of the included *app_.set* file to initialize the application. When an operator types the word HUMIDITY from the control console, the command decoder activates the *humd_cmd()* function at line 19. The *switch* statement at line 23 selects a control function on the basis of the first character after the comma that delimits the command.

If the operator enters '!' to select the Terminate function, then the statements in lines 24 and 25 reset the global variables *humd_control* and *humd_profile*. The humidity control and profile routines detect the values of those variables and terminate their functions when the values go to zero.

If the operator enters 'S' to select the Setpoint Control function, then at line 28 the program extracts the value of the relative-humidity setpoint and places it in the global variable *humd_setp*. The *humd_control* flag indicates the status of the humidity-control routine; if the routine is not already active (flag = 0), then the *push_go* function at line 30 places it on the activation stack.

If the operator selects the function Profile (P), then the monitor extracts the profile parameters at line 34 and, if necessary, places the profile routine on the activation stack. At line 41 the program sets the *humd_profile* variable to −1 to signal the *humd_pro* routine that a new profile is required.

The *humd_ctl()* routine at line 46 uses the variable *humd_control* both to detect and to signal the state of the control process. A value of 0 is a signal to terminate the process. The *return(0)* statement at line 51

Listing 5—Supplemental files

```
                         "DEFS.H" File

#define  APP1         1  /*application compiled  */
#define  APP2         0  /*application not compiled      */

#if APP1
#include "app1.def"      /*switches, addresses, etc.     */
#endif

#if APP2
#include "app2.def"
#endif

#ifndef ALL SWITCHES     /*these three statements for    */
#define ALL SWITCHES 0   /*every switch used     */
#endif

                        "APP_.DEF" File

#define  Z80         1   /*app runs on Z80 processor     */
#define  GO_SIZE    16   /*control stack size    */
#define  NBR_CMDS    8   /*number of operator commands   */
#define  HUMD_PUMP  0xFF00      /*hardware address of air pump  */
#define  HUMD_AIR   0xFF01      /*hardware address of air valve */
#define  HUMD_AD     2   /*humidity sensor mux address   */
#define  HUMD_TOL    5   /*humidity tolerance*/
#define  HUMD_DRY    0   /*valve off for dry air */
#define  HUMD_MOIST 1    /*valve on for moist air        */


                        "APP_.SET" File

humd_set();     /*initialize application        */

                         "EXTE.H" File

extern struct {int  (*func)();/*Function Pointer stack. */
                  int  parm;
               } go[];
extern char go_sptr;

extern struct {int  (*func)();/*operator command array  */
                  char  *cmnd;
              } command[];

extern char  new_second, operator_input[];
extern int   a_to_d[];  /*sensor data from interrupt    */
```

instructs the monitor to remove the routine from the activation stack. A value of 1 is a signal to initialize the process. Values of 2 or 3, which can be set by the *humd_ctl()* routine, tell other routines the state of the control process. If the humidity is not at the setpoint (plus or minus some tolerance), then moist or dry air is valved in and *humd_control* is set to 2. If the humidity is at the setpoint, then the air pump is turned off and *humd_control* is set to 3.

The *humd_pro* function at line 70 uses the parameter passed from the activation stack for timekeeping. *Parm* is incremented once for each second that the measured humidity remains at the required setpoint. That process continues until *parm* becomes equal to the setpoint-dwell time (*humd_step_time*). The setpoint is then changed and *parm* is set to 1 to begin timing a new point—this routine can't set *parm* to zero, because that would tell the monitor to terminate the routine.

At line 75, the global variable *humd_profile* is used to initialize or terminate the routine. The local variable *update* signals when a new humidity point is called for. Dwell time is accumulated and tested at line 81. When a new point is required, the dwell-time accumulator is cleared and a new humidity-control point is passed to *humd_ctl* by the *humd_setp* variable. If the *humd_ctl* routine is inactive, as it may be at the first profile entry, then it is placed on the activation stack at line 95. When all profile points have been processed, the control functions are terminated at line 89.

The humidity-control example, albeit windy, demonstrates the operation of a monitor that uses function pointers to control applications

Listing 6—A typical application program

```
1      #include "defs.h"                /*define application       */
2      #include "exte.h"        /*declare external identifiers  */
3
4      int  humd_cmd(), humd_ctl(), humd_pro();
5      char humd_control, humd_profile;
6      char humd_nsteps, humd_step_nbr, humd_step[10];
7      int  humd_setp, humd_step_time;
8
9      /*         routine to initialize humidity application    */
10     humd_set()
11     {
12     command[0].func=humd_cmd;        /*initialize command array       */
13     command[0].cmnd="HUMIDITY,";
14     ...
15     humd_control=humd_profile=0;     /*initialize variables  */
16     }
17
18     /*           routine to process HUMIDITY, command          */
19     humd_cmd( cp )  /*process the "HUMIDITY," command          */
20     char *cp;       /*'cp' is pointer to next                  */
21     {               /*character in the command string          */
22
23     switch( *cp )
24      {case '!': humd_control=0;      /*HUMIDITY,! to abort control    */
25                 humd_profile=0;
26                 return;
28       case 'S':              /*      enter single set point  */
29        {humd_setp=<extract numeric set point>;
30         if( !humd_control )          /*control not active      */
31          {push_go( humd_ctl,0);      /*start control routine */
32              humd_control=1;}        /*show new control point         */
33         return;}
34       case 'P':              /*      enter control profile   */
35        {humd_step_time=<extract point dwell time>;
36         humd_nsteps=0;
37         do          /*      extract control points          */
38          {humd_step[humd_nsteps++]=<extract point by *(cp++)>;}
39         while( *cp );
40             /*activate profile if inactive  */
41         if( !humd_profile ) push_go( humd_pro,1);
42         humd_profile=-1;})           /*new profile flag      */
43     return;
44     }
45     /*           routine to control chamber humidity                 */
46     humd_ctl()
47     {
48
49     switch( humd_control )
50      {case 0: outp(HUMD_PUMP,0);     /*turn off air pump      */
51               return( 0 );           /*terminate routine      */
52       case 1: <initialize application>
53       case 2:                /*2 and 3 entry is equivalent   */
54       case 3:                /*for this routine              */
55        {if( (a_to_d[HUMD_AD] - HUMD_TOL) < humd_setp )
56          {outp(HUMD_PUMP,1);         /*humidity is low. turn on air  */
57           outp(HUMD_AIR,HUMD_MOIST);/*and valve in moist air         */
58           humd_control=2;}           /*show not at set point */
59         else
60          {if( (a_to_d[HUMD_AD] + HUMD_TOL) > humd_setp )
61            {outp(HUMD_PUMP,1);       /*   humidity is high   */
62             outp(HUMD_AIR,HUMD_DRY);  /* valve in dry air    */
63             humd_control=2;}
64           else               /*  humidity is at set point    */
65            {outp(HUMD_PUMP,0);       /*  turn off pump       */
66             humd_control=3;}}}})     /*show at set point     */
67     return( 1 );                     /*  continue routine    */
68     }
69     /*           routine to control a humidity profile               */
70     humd_pro( parm )
71     int parm;
72     {
73     char update;
74
75     if( !humd_profile ) return(0);  /*  terminate routine    */
76     if( humd_profile == -1 )        /*do a new profile       */
77      {humd_profile=1;               /*reset start flag       */
78       update=1;             /*send new point to 'humd_ctl'  */
```

You can add new functions or adapt a system to new hardware with a stack-of-function-pointers monitor.

that are not known to the monitor. It is only one of many applications that may be active in a system at any given time. When many applications run concurrently, the time that each controls the system becomes an important concern. The humidity-control example is trivial in that respect, because each entry takes only a few milliseconds. For longer tasks, it is often necessary to divide the computation into a series of steps to be accomplished during multiple entries.

Consider a system that, once per hour, archives 1000 measurements at 100 msec per operation—requiring a total of 100 sec. If the other tasks in the system cannot wait 100 sec for service, the programmer must subdivide the task into smaller steps. When you're deciding whether or not to use a stack-of-function-pointers type of monitor, an important consideration is that tasks should not require service on a regular time schedule. Time-critical routines may be serviced by interrupt control. However, all others will get their share of processor resources at varying times, depending upon what the other routines on the stack are doing. The form of the statement at line 45 in **Listing 4** reflects processing delays. If some process ties up the processor for several seconds, then the value of *new_second* (incremented under interrupt control) will be greater than 1. If *new_second* were simply reset, rather than being decremented, then routines that depend upon that variable for timekeeping would lose time.

Listing 6—A typical application program *(continued)*

```
      humd_step_nbr=0;}     /*   start at point 0           */
    else update=0;

    if( humd_control == 3 )         /*humidity at set point */
     {if( new_second )              /*new second this entry */
       {parm++;             /*accumulate time in seconds    */
        if( parm == humd_step_time )
         {update=1;}}}      /*  time for a new point        */

    if( update )            /*change humidity set point     */
     {if( humd_step_nbr == humd_nsteps )
       {humd_profile=0;     /*have completed profile        */
        humd_control=0;     /*terminate control routines    */
        return( 0 );}
      humd_setp=humd_step[humd_step_nbr++]; /*new control point    */
      parm=1;               /*      reset dwell time        */
      if( !humd_control )   /*must start control routine if */
       {push_go( humd_ctl, 1);      /*it is inactive        */
        humd_control=1;}}
    return( parm );
    }
```

Organize source code into three categories

You'll be able to keep better track of your source-code modules (and will also save a considerable amount of compilation time) if you split them among three categories of files. The first category consists of only one relatively small file, which contains the monitor code. However, you may have to recompile the monitor several times because each new application requires the addition of an *#include* statement for the corresponding *app_.def* file. Further, the initialization code contained in the corresponding *app_.set* file becomes part of the monitor code and must be debugged.

The second category also consists of one file, containing utility routines that are used in many applications. That file may be quite large but, because the routines are already debugged, you'll generally have to compile it only once for each new application. The required routines are selectively compiled by switches defined in the *app_.def* file.

The third category consists of files containing application-specific source code. These files are generally of moderate size. However, changes in requirements and modifications dictated by debugging runs may require you to recompile any or all of these files many times during software development.

Often, several different software applications run in the same hardware system. Also, a particular software application may run on several different hardware/software systems. Thus, confusion can arise about what version of the code is needed for any given system. You can reduce this confusion by organizing your files into directories of two types.

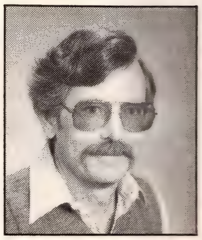
The first type consists of one directory that is common to all your projects. This directory always contains the current source code for the monitor and the utility routines, which are common to many applications. Any modification to that code will affect all systems and will automatically implement enhancements and correct defects as and when you recompile the various systems. You should also keep the *defs.h* and *exte.h* files in this directory.

The second type consists of a separate directory for each hardware/software system. This system directory should contain the source-code files for applications used only in that system, as well as the *app_.def* and *app_.set* files, the object-code files, and any batch files used to compile and link that particular system. Also, it is good practice to copy into the system directory, from the monitor/utility directory, the source files that you used to compile the system in its most recent configuration.

Once you have established a basic framework of the monitor and one or two applications, you can easily add applications to the family by performing six simple tasks: defining the application key *APP_* and placing the selective include in the *defs.h* file; placing the selective include of *app_.set* in the *monitor* program; placing code to initialize the application in file *app_.set*; adding the commands and processing-function names to the command array; coding the routines to perform the application in files *xxx.c*; and adding *xxx.obj* to the linker/loader.

The main criterion for deciding whether or not to use the stack-of-function-pointers operating system is timing. The system is not appropriate for fast systems where the time overhead for examination of a stack would be significant, and it is not appropriate for systems in which routines *must* be serviced at precise time intervals. However, the stack-of-function-pointers operating system is a versatile tool for those who program several systems or instruments. It's easy to code, and it provides monitor and control functions that simplify application-software design. The Desert Research Institute uses the same stack-of-function-pointers monitor and utility code for remote-site Z80-, NSC800-, and PC-based data loggers; a PC-based, central-site polling system for those data loggers; and numerous single-board, instrument-control processors. EDN

Author's biography



Rick Brown is an associate research engineer at the Desert Research Institute of the University of Nevada, where he has worked for 18 years. Rick's prime responsibility is the development of scientific instruments and instrumentation systems. He holds a BSEE from the University of Florida and is a member of the IEEE. He also runs a consulting service specializing in the design of embedded-processor systems. In his spare time he enjoys mountain climbing, skiing, and back-country travel.

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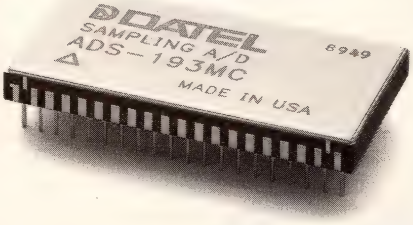

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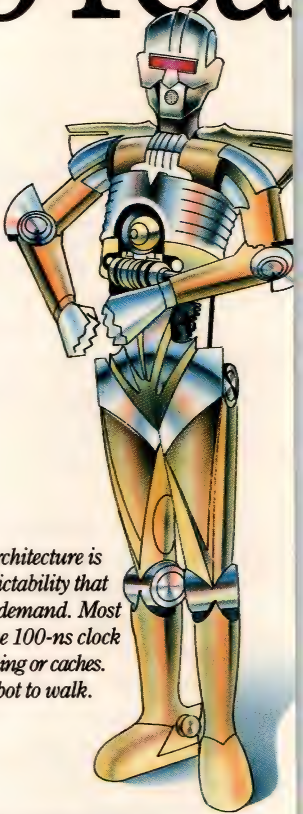

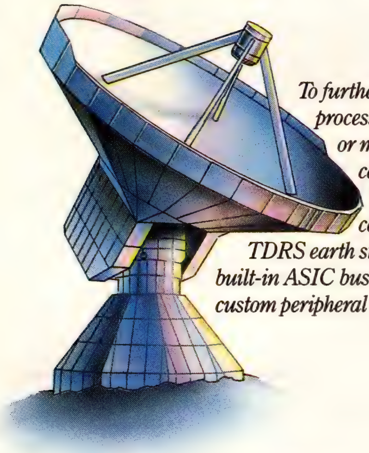

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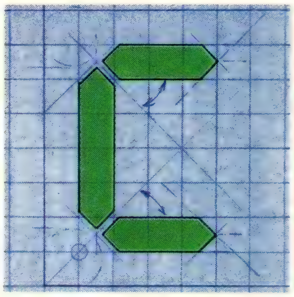

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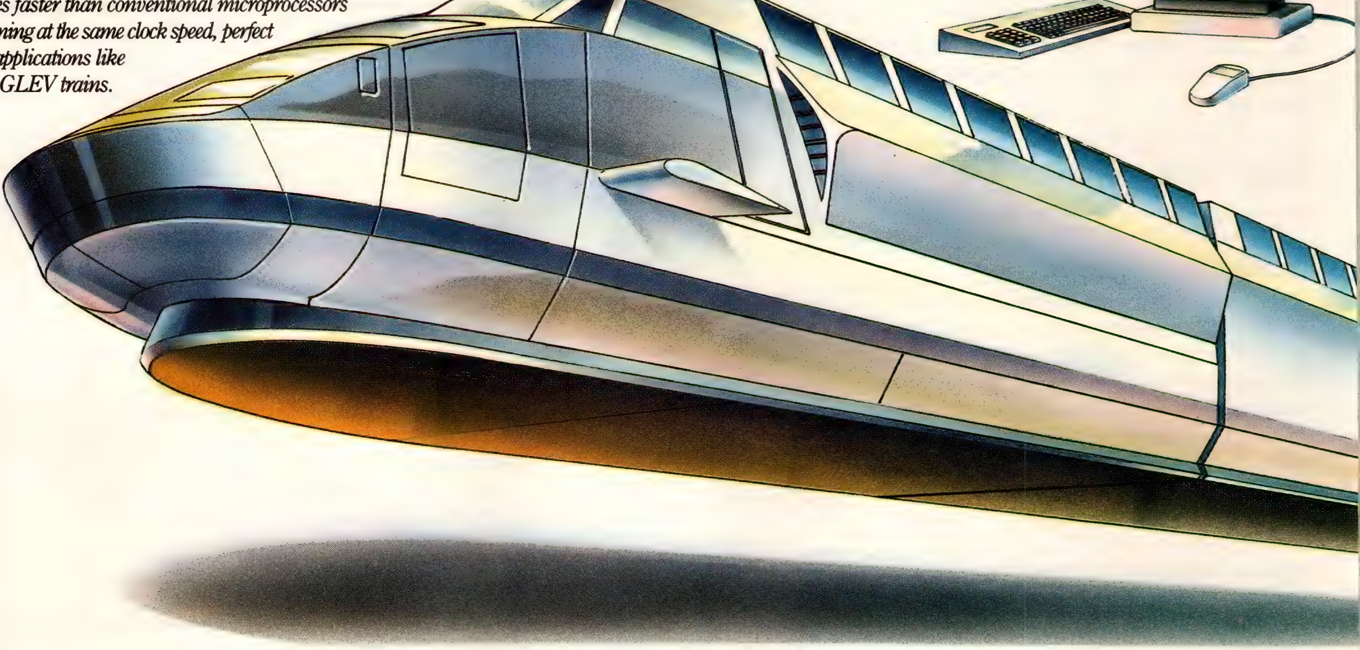

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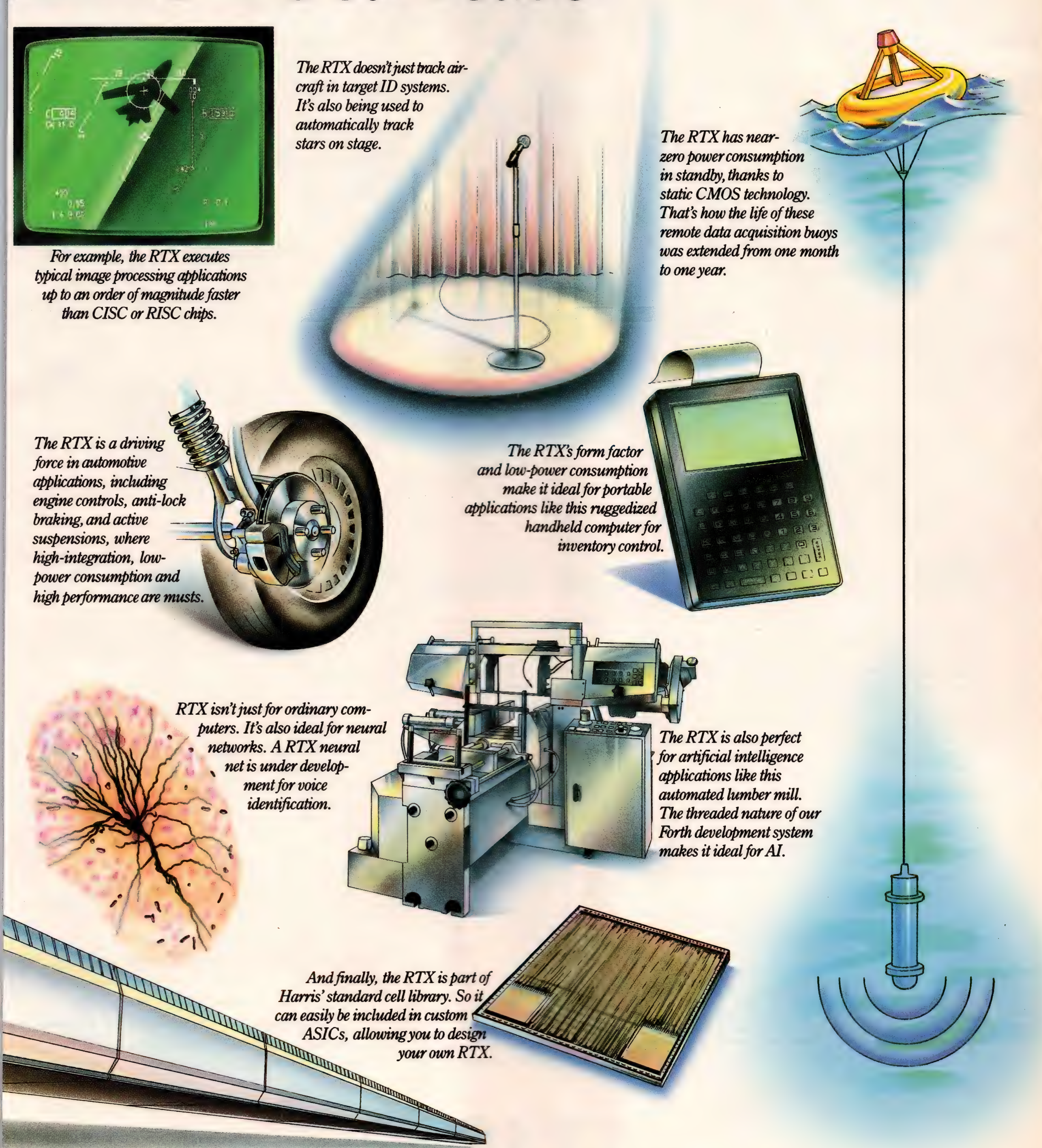

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ERROR TERMS (µV)					
Vos MAX	50	100	90	60	75
Ios MAX x 25kΩ	6	70	50	70	4
MIN Gain 10V out	14	5	3	5	50
MIN CMRR ±25V in	22	20	13	22	39
MIN PSRR Vs = ±15V ±10%	6	9	9	9	9
SUM OF ALL ERROR TERMS (µV)	**98**	**204**	**165**	**166**	**177**
0.1Hz to 10Hz NOISE (µVp-p)					
Voltage Noise	0.50	0.38	0.23	0.38	0.50
Current Noise x 50kΩ	0.11	0.75	0.70	0.75	0.10
Resistor Noise	0.55	0.55	0.55	0.55	0.55
RMS SUM (µVp-p)	**0.75**	**1.00**	**0.92**	**1.00**	**0.75**
DRIFT WITH TEMP (µV/°C)					
MAX TCVos	1.0	1.2	1.0	1.2	2.0
MAX TCIos x 25kΩ	0.1	2.1	1.0	2.1	0.2
SUM OF DRIFT TERMS (µV/°C)	**1.1**	**3.3**	**2.0**	**3.3**	**2.2**
MAX SUPPLY CURRENT (µA)	**560**	**2000**	**3000**	**2000**	**600**
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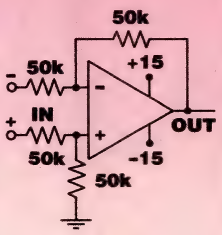

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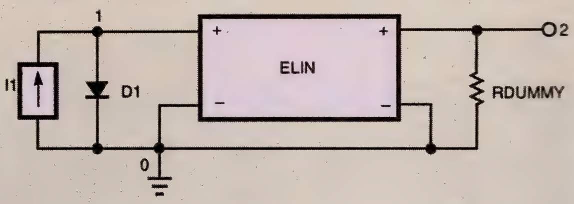
EDITED BY CHARLES H SMALL & ANNE WATSON SWAGER

PSpice model simulates temperature sensor

Horace T Jones
ITE Inc, Beltsville, MD

Fig 1's PSpice model simulates temperature-to-voltage conversion. The model produces an output voltage at node 2 that is numerically equal to the temperature in degrees Celsius. If you combine it with voltage-controlled R, C, L, or G models, you can simulate the effects of temperature variation on a component's value.



```
.SUBCKT TEMPSENS 2
****************VTEMP
I1 0 1 1MA
D1 1 0 DTEMPSENS
ELIN 2 0 POLY(1) 1,0  3.09372E2  -4.26709E2
+  -1.29193E2  +1.25265E2  -7.06356E1
RDUMMY 2 0 1G
.MODEL DTEMPSENS D(IS=1E-13)
.ENDS TEMPSENS
```

***Fig 1—This PSpice model simulates a circuit that senses** temperature variations and outputs a corresponding voltage.*

ELIN is a voltage-controlled voltage source whose input at node 1 is not a linear function of temperature. The model linearizes this temperature-voltage relationship using the results of a previous PSpice run and a curve-fitting algorithm. First, a PSpice file measured the forward voltage of the temperature-sensing diode, DTEMPSENS, at temperatures between −20 and +70°C in 10° increments. The curve-fitting program reported the power-series coefficients that represent the curve passing through various X,Y points. In this model, X corresponds to the voltage through DTEMPSENS, and Y corresponds the DTEMPSENS's temperature.

Fig 1's model for ELIN uses the coefficients that the curve-fitting program reported for fourth-order power series as follows:

$$V(2) = P0 + P1 \cdot V(1) + P2[V(1)^2] + P3[V(1)^3] + P4[V(1)^4],$$

where $P0 = 3.09372E2$, $P1 = -4.26709E2$, $P2 = -1.29193E2$, $P3 = 1.25265E2$, and $P4 = -7.06356E1$. EDN

To Vote For This Design, Circle No. 742

Fan controller minimizes audible noise

James K Koch
Hewlett-Packard, Roseville, CA

To accommodate both high and low thermal loads, the circuit in **Fig 1** senses the temperature inside an enclosure and modifies a fan's drive voltage accordingly. If the temperature is below some threshold, the circuit operates the fan at a reduced voltage. This procedure considerably reduces audible noise while maintaining adequate cooling.

The circuit is composed of three major sections: a temperature sensor, a comparator, and a regulator. The LM3900 Norton amplifier responds to differential input current rather than voltage. However, IC_{1A} does not operate in Norton mode; it operates as a voltage amplifier. Pin 3 is one diode drop above ground, and the magnitude of this diode drop varies with temperature. The normal negative temperature coefficient of the diode is about 2.5 mV/°C. IC_{1A}'s gain is approximately 15, so its dc output at 25°C is around 0.6V × 15, or 9V. The temperature coefficient of IC_{1A}'s output is about −2.5 mV × 15, or −37.5 mV/°C. (Note: This temperature-sensing method is an application suggested by National Semiconductor in its Linear Applications Handbook.)

The 12V supply and R_2 determine the plus input current of the comparator. The temperature sensor's output and R_1 determine the minus input current of the comparator. The threshold voltage, V_T, is the voltage at the temperature sensor's output that makes these two currents equal. For this particular circuit,

$$V_T = 0.6V + (12V - 0.6V)(62k/100k) = 7.67V.$$

When the temperature of the circuit rises, the dc level at IC_{1A}'s output decreases from its 25°C level of 9V. When this output reaches 7.67V, the output of IC_{1B} goes high. R_3, R_4, and R_5 provide 3.5 mV/°C of hysteresis to prevent chatter on the comparator output.

When the circuit's first stage senses a temperature above the threshold, IC_{1B}'s high output turns on Q_2 so that almost all of the supply's 12V appears across the fan. For temperatures below a set threshold, IC_{1B}'s output goes low, which reduces the base current supplied to Q_2. Q_2's collector voltage then rises to about 5 diode drops above ground. At this point, D_1, D_2, and D_3 start conducting and provide base current to Q_2 through Q_1. Q_2's collector voltage is relatively independent of the fan's current and clamps at about 5×0.6V or 3V. As a result, the voltage drop across the fan decreases to 9V, and the fan runs more quietly.

Because IC_1 contains the temperature sensor, you must locate this IC at the point in your circuit that's best for monitoring temperature. You can adjust R_1 to set the appropriate temperature threshold. Experiments with 12V brushless dc fans from several manufacturers show that these fans can operate on dc voltages as low as 7V. However, to guarantee that the fan starts reliably, you should provide it with at least 9V.

To Vote For This Design, Circle No. 743

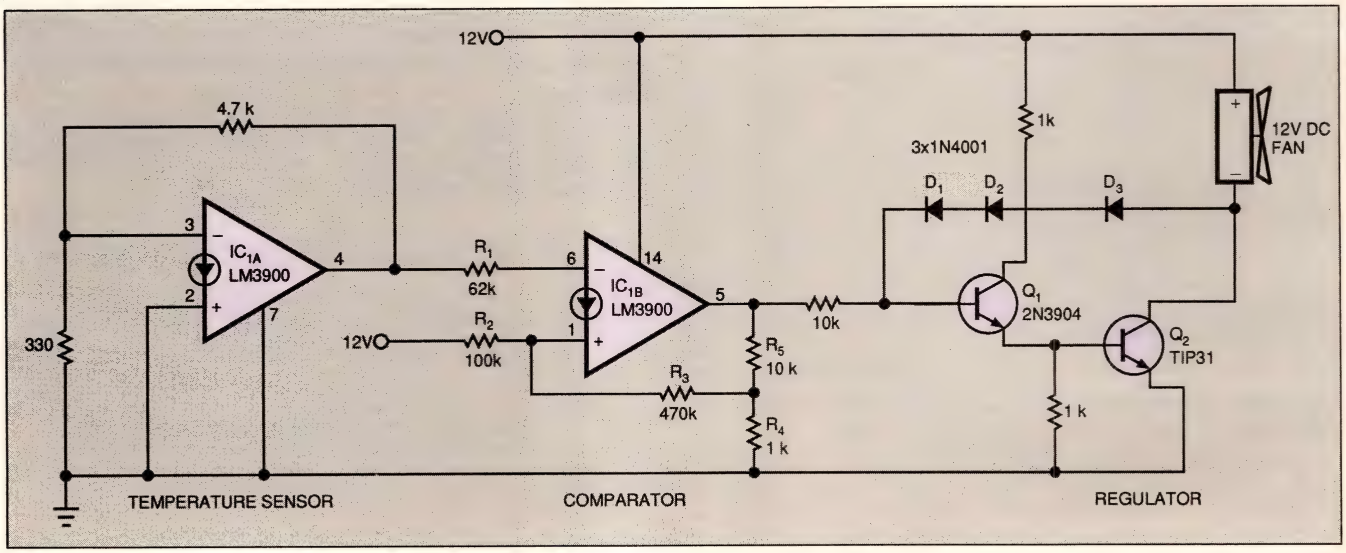


Fig 1—Instead of always running a fan *at its maximum voltage (and noise), you can use this circuit to sense low thermal loads and run the fan a little quieter.*

Calculator program aids filter design

Jimmy D Slife
XEL Communications Inc, Aurora, CO

The HP-41C calculator program in **Listing 1** computes resistor values for both multiple-feedback bandpass (MFBP) and dual-amplifier bandpass (DABP) filters. MFBP and DABP filters **(Fig 1)** are narrow bandpass filters: The ratio of the higher cutoff frequency to the lower cutoff frequency is less than 2:1. An MFBP filter uses a single op amp and features modest performance; a DABP filter uses two op amps, which improves the filter's performance and sensitivity factors. MFBP and DABP filters are useful for Q values as great as about 20 and 150, respectively. The gain of a DABP filter is always 2, unless you split the input resistor into two resistors, R_{1A} and R_{1B}. R_{1A} takes the place of R_1, and from

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MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8☐	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

NOTE: Minimum gain at highest frequency point and over full temperature range.
• 1dB Gain Compression
☐ +4dBm 1 to 2 GHz

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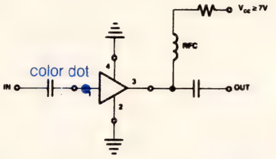

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*MAR-8, Input/Output Impedance is not 50ohms, see data sheet. Stable for source/load impedance VSWR less than 3:1

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Size (mils)	Tolerance	Temperature Characteristic	Value
80 × 50	5%	NPO	10, 22, 47, 68, 100, 220, 470, 680, 1000 pf
80 × 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 × 60	10%	X7R	.022, .047, .068, .1μf

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C113-Rev. D

CIRCLE NO. 133

R_{1B} is an additional resistor in parallel with capacitor C.

The DABP and MFBP sections of the program are independent; you can enter either one. You run the programs by keying in XEQ "MFBP" or XEQ "DABP". You can also use the programs in "USER" mode: The following four functions are available by pressing the first four top row keys on the HP-41C:

- A—Program calculates resistor values for an MFBP filter given the capacitor values; frequency; gain; and quality factor, Q.
- B—Program calculates MFBP-filter performance based on actual resistor and capacitor values.
- C—Program calculates sensitivities of the filter's performance to component-value variations.
- D—Program calculates resistor values for DABP filters.

To obtain an HP-28S version of the program, send a self-addressed, stamped envelope to the author at 3049 S Winston St, Aurora, CO 80013. EDN

To Vote For This Design, Circle No. 744

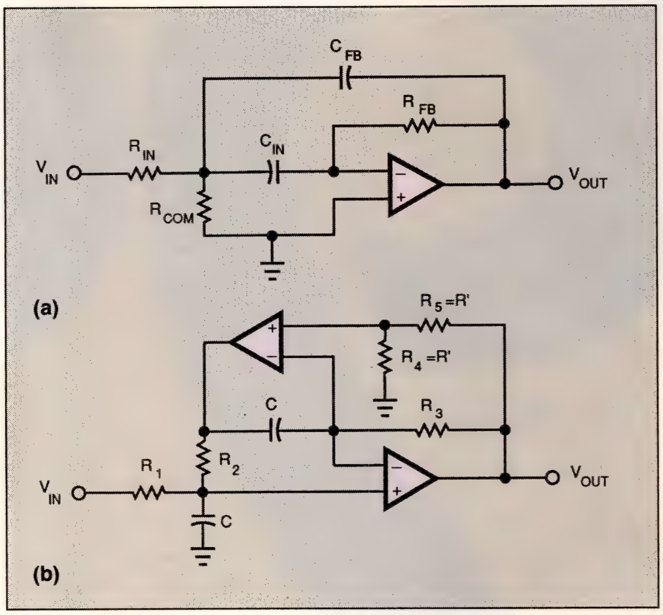


*Fig 1—**The filter-design program calculates** resistor values and checks the filter response for these multiple-feedback **(a)** and dual-amplifier **(b)** narrow bandpass filters.*

Listing 1—Filter-design program

```
 PRP "MFBP"

01♦LBL "MFBP"
 02 CF 27

 03♦LBL A
 04 "CFB"
 05 PROMPT
 06 STO 01
 07 "CIN"
 08 PROMPT
 09 STO 02
 10 /
 11 SQRT
 12 STO 00
 13 RCL 02
 14 RCL 01
 15 /
 16 SQRT
 17 ST+ 00
 18 "Q? "
 19 PROMPT
 20 X↑2
 21 RCL 00
 22 X↑2
 23 *
 24 STO 08
 25 RCL 01
 26 RCL 02
 27 +
 28 RCL 02
 29 /
 30 "GAIN?"
 31 PROMPT
 32 *
 33 STO 06
 34 "F0? "
 35 PROMPT
 36 X↑2
 37 PI
 38 X↑2
 39 *
 40 4
 41 *
 42 RCL 01
 43 *
 44 RCL 02
 45 *
 46 STO 07
 47 RCL 08
 48 X<>Y
 49 /
 50 SQRT
 51 STO 03
 52 "RFB="
 53 ARCL X
 54 AVIEW
 55 STOP
 56 RCL 03
 57 RCL 06
 58 /
 59 "RIN="
 60 ARCL X
 61 AVIEW
 62 STOP
 63 RCL 03
 64 RCL 08
 65 RCL 06
 66 -
 67 /
 68 "RCOM="
 69 ARCL X
 70 AVIEW
 71 STOP
 72 GTO A
 73♦LBL B
 74 "CFB"
 75 PROMPT
 76 STO 01
 77 "CIN"
 78 PROMPT
 79 STO 02
 80 /
 81 SQRT
 82 STO 00
 83 RCL 02
 84 RCL 01
 85 /
 86 SQRT
 87 ST+ 00
 88 "RIN"
 89 PROMPT
 90 STO 05
 91 1/X
 92 "RCOM"
 93 PROMPT
 94 1/X
 95 +
 96 STO 04
 97 "RFB"
 98 PROMPT
 99 STO 03
100 *
101 SQRT
102 RCL 00
103 /
104 "Q="
105 ARCL X
106 AVIEW
107 STOP
108 RCL 04
109 RCL 03
110 /
111 RCL 01
112 /
113 RCL 02
114 /
115 SQRT
116 2
117 /
118 PI
119 /
120 STO 09
121 "F0="
122 ARCL X
123 "├HZ"
124 AVIEW
125 STOP
126 RCL 01
127 RCL 02
128 +
129 RCL 05
130 *
131 1/X
132 RCL 03
133 *
134 RCL 02
135 *
136 "VGAIN="
137 ARCL X
138 AVIEW
139 STOP
140 LOG
141 20
142 *
143 "VdB="
144 ARCL X
145 "├dB"
146 AVIEW
147 STOP
148 GTO B
149♦LBL C
150 "S R1,C1,C2=-1/2"
151 AVIEW
152 STOP
153 -1
154 ENTER↑
155 PI
156 ENTER↑
157 *
158 8
159 *
160 RCL 05
161 *
162 RCL 03
163 *
164 RCL 01
165 *
```

Listing 1—Filter-design program *(continued)*

```
 166 RCL 02
 167 *
 168 RCL 09
 169 X↑2
 170 *
 171 /
172 "SENSR1="
 173 ARCL X
 174 AVIEW
 175 STOP
 176 GTO C

 177♦LBL D
178♦LBL "DABP"
 179 "F0?"
 180 PROMPT
 181 STO 10
 182 "C?"
 183 PROMPT
 184 STO 09
 185 *
 186 PI
 187 ENTER↑
 188 +
 189 *
 190 1/X
191 "R,R2,R3="
 192 ARCL X
 193 AVIEW
 194 STOP
 195 "Q?"
 196 PROMPT
 197 *
 198 STO 07
 199 "R1="
 200 ARCL X
 201 AVIEW
 202 STOP
203 "GAIN,<2?"
 204 PROMPT
 205 STO 06
 206 RCL 07
 207 2
 208 *
 209 RCL 06
 210 /
 211 "R1A="
 212 ARCL X
 213 AVIEW
 214 STOP
 215 RCL 06
 216 *
 217 2
 218 ENTER↑
 219 RCL 06
 220 -
 221 /
 222 "R1B="
 223 ARCL X
 224 AVIEW
 225 STOP
226 GTO "DABP"
 227 END
```

Negative regulator begets dual supply

Lance M Towers
Rockwell International Autonetics, Anaheim, CA

With a few limitations, a negative-voltage regulator can function as a dual-voltage supply. This negative-regulator scheme is less expensive and provides more current than a true dc/dc converter. But this circuit must have more current flowing in its positive-output leg than its negative-output leg (the regulator can only sink current). Also, its load must have an isolated ground.

Note in **Fig 1**'s circuit that the negative-voltage regulator, IC_1, has its input-voltage pin connected to input ground. The IC's usual main output supplies the ground reference for the load. Thus the input-single-supply's positive and ground levels are the load's positive and negative rails, respectively.

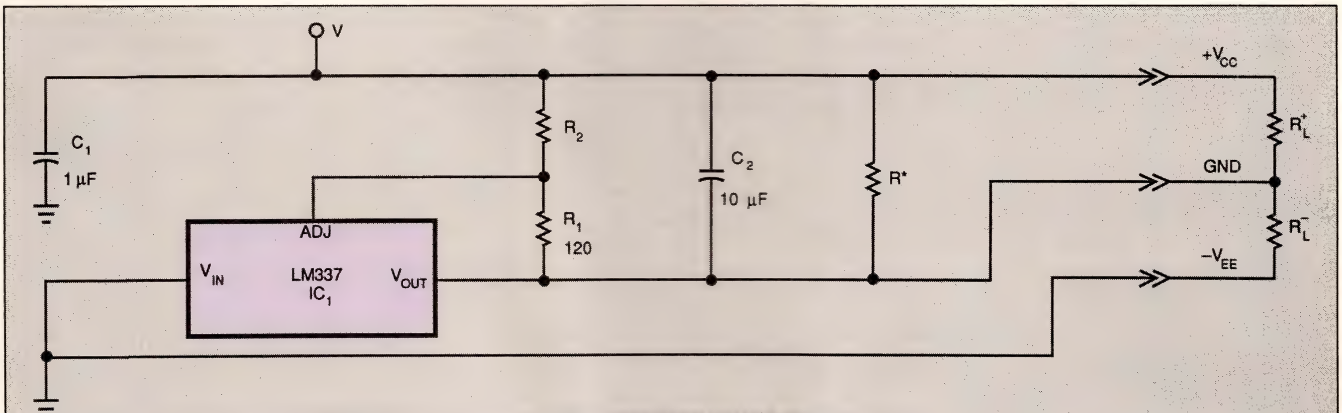
During operation, R_2 determines the load's $+V_{CC}$. Therefore,

$$+V_{CC} = 1.25(1 + (R_2/120)).$$

For a bipolar supply with equal outputs,

$$R_2 = 120(0.4(+V) - 1).$$

To Vote For This Design, Circle No. 745



NOTE: *R MAY BE REQUIRED TO ENSURE LINEAR OPERATION. SELECT R* SO THAT THE CURRENT FROM $+V_{CC}$ TO GND IS ≧ TO THE CURRENT FROM GND TO $-V_{EE}$.

Fig 1—Subject to some limitations, *a negative-voltage regulator can replace a bipolar dc/dc converter.*

Bender senses shocks

Don Sherman
Maxim Integrated Products, Sunnyvale, CA

With the aid of a simple mounting system and some soldered-on weights, a piezoelectric "bender" can detect mechanical shocks. The bender comprises a piezoelectric-ceramic element bonded to a thin brass disc. Such assemblies form the heart of many telephone annunciators and wrist-watch or panel-mounted alarms.

Depending on the mounting scheme, the bender can sense shocks in one axis, **Fig 1a**, or three axes, **Fig 1b**. For 1-axis sensing, solder one edge of the bender to a mounting bolt. Opposite the mounting bolt, solder a weight to increase the bender's sensitivity. A small hook affixed to the mounting substrate limits motion so that the brittle piezoelectric element will not crack.

For 3-axis sensitivity, solder one edge to a mounting bolt as before. At the other edge, solder a flat-head bolt that points away from the mounting substrate. Use a pair of jam nuts to increase the assembly's polar moment of inertia. The jam nuts' position determines the bender's sensitivity.

In both cases, apply your soldering iron as briefly as possible to the bender to avoid damaging the piezoelectric element's bond to the brass disc.

Fig 2 shows a simple alarm circuit. Giving the bender a good smack will develop several volts across R_1, the 10-MΩ resistor. The dual-timer IC, IC_1, will then pulse the output alarm for one minute at a 1-Hz rate. The alarm has its own driver circuit and sounds a piercing 90-dB tone when energized.

The bender and alarm are both available from Projects Unlimited, Dayton, OH.

To Vote For This Design, Circle No. 746

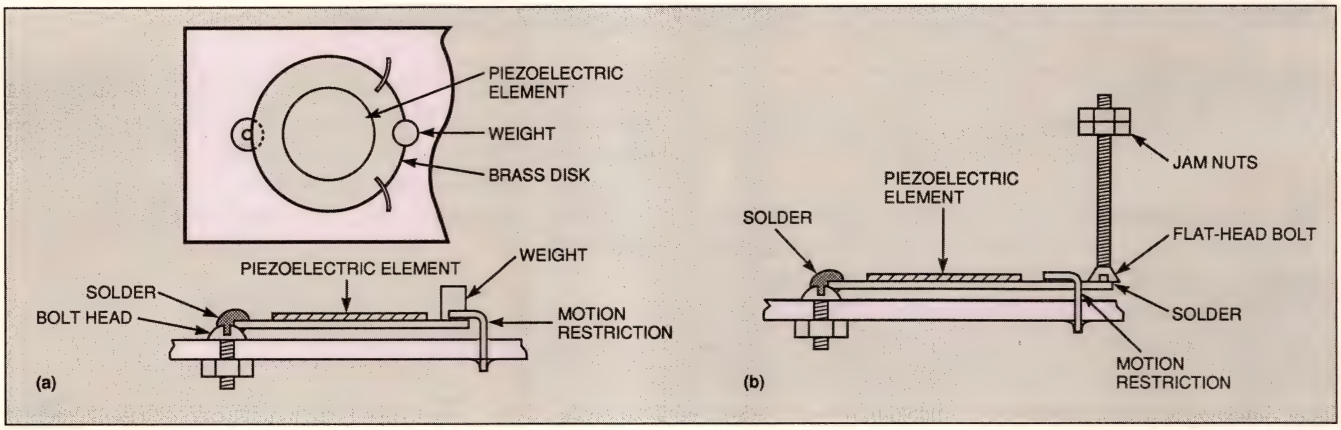


Fig 1—Solidly mounting one end of a *piezoelectric "bender" and affixing a weight to the opposite edge transforms the bender into a shock sensor. Here,* ***a*** *is sensitive to vertical-axis shocks only;* ***b*** *senses shocks in all three axes.*

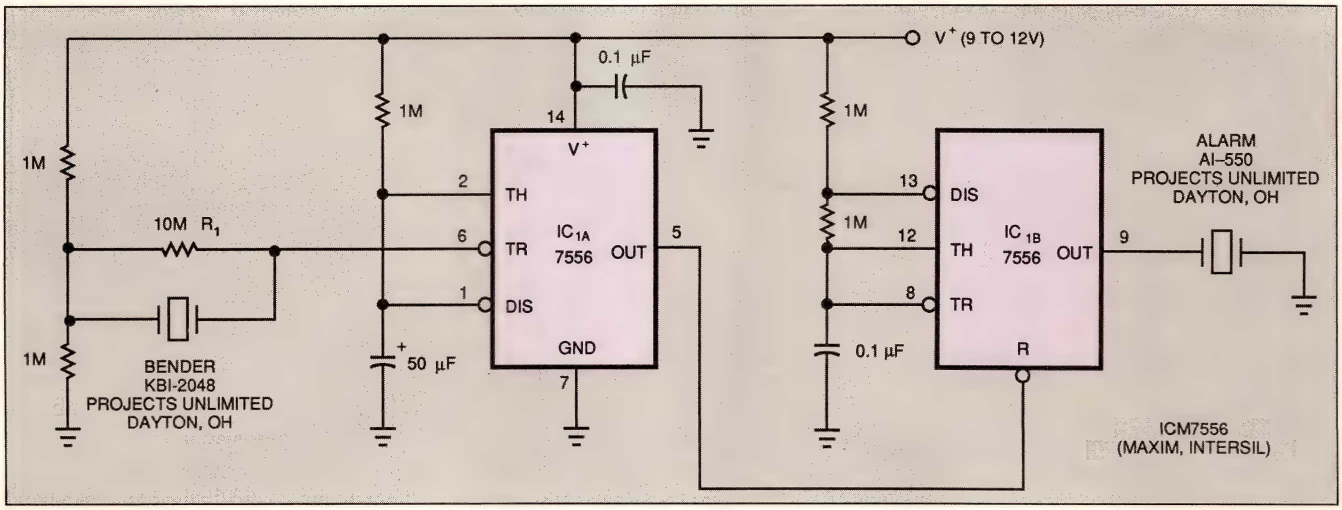


Fig 2—The circuit sounds a 1-sec alarm *whenever you give the bender a good smack.*

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G. Wayne Hawk
CEO/Acme Electric Corporation
East Aurora, New York 14052
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CIRCLE NO. 134

Self-modifying code identifies µP type

László Szilágyi
Technical University of Budapest, Budapest, Hungary

The self-modifying program in **Listing 1** identifies different members of the 80X86 family by figuring out how long their prefetch queues are. You can use the routine to let your programs adapt to various 80X86 µPs at runtime.

This program will bomb if you run it under a debugger. The debugger won't handle the queue properly and will branch to a wrong address. The program segments in **Listing 2** take advantage of this side effect to protect against software pirates. You can insert these segments in your 80X86 programs to foil hackers who may pick over your programs with a debugger.

EDN

To Vote For This Design, Circle No. 747

Listing 1—Processor-identification program

```
;Determine the type of the processor by means of the queue length

                TITLE           3.EXAMPLE
code            SEGMENT
                ASSUME  cs:code,ds:code
PR_STRING       EQU     09h
RET_TO_DOS      EQU     4ch
DOS             EQU     21h
CR              EQU     0dh
LF              EQU     0ah
                ORG     100h
start:          mov     ax,cs
                mov     ds,ax                   ;ds==cs
                cli                             ;disable IT
                xor     bx,bx                   ;bx==0
                lea     si,c1+1                 ;si==address of byte to be modified
                mov     BYTE PTR [si],bl        ;modifying
                nop                             ;fill in the queue
                nop                             ;fill in the queue
c1:             mov     bl,1                    ;if queue length>4 byte, bl==1
                                                ;else bl==unchanged
                lea     si,c2+1                 ;si==address of byte to be modified
                mov     BYTE PTR [si],bl        ;modifying
                nop                             ;fill in the queue
                nop                             ;fill in the queue
                nop                             ;fill in the queue
                nop                             ;fill in the queue
c2:             mov     bl,2                    ;if queue length>6 byte, bl==2
                                                ;else bl==unchanged
                sti                             ;enable IT

                add     bx,bx                   ;bx==2*bx
                mov     dx,[addr_vec+bx]
                mov     ah,PR_STRING
                int     DOS                     ;display the corresponding string
                                                ;according to the type of
                                                ;the processor

                mov     ah,RET_TO_DOS
                int     DOS                     ;exit to DOS
txt0            DB      CR,LF,'Processor: i8088',CR,LF,'$'
txt1            DB      CR,LF,'Processor: i8086 or i80286',CR,LF,'$'
txt2            DB      CR,LF,'Processor: i80386',CR,LF,'$'
addr_vec        DW      txt0
                DW      txt1
                DW      txt2
code            ENDS
                END     start
;(You mustn't trace this program beacuse the result may be false!)
```

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Listing 2—Hacker-foiling segments

```
;       2/a. EXAMPLE
        .
        .
        .
        mov     al,c2           ;false address
        lea     si,c0+1         ;address of byte to be modified
        .
        .
        .
        cli                     ;disable IT
        mov     [si],al         ;overwrite  the next instruction
c0:     jmp     SHORT c1        ;if trace is active, jump c2
        .                       ;else jump  c1
        .
        .
c1:     sti                     ;enable IT
        .
        .
        .



;       2/b. EXAMPLE
        .
        .
        .
        mov     al,90h    ;code of NOP instruction
        lea     si,c0     ;address of byte to be modified
        .
        .
        .
        cli               ;disable IT
        mov     [si],al   ;overwrite the next instruction
c0:     sub     si,di     ;any two-byte-long instruction
                          ;if trace is active, false instructions
                          ;will be occured
        sti               ;enable IT
        .
        .
        .
```

Program automates Quine-McCluskey method

Earles L McCaul
Hughes Aircraft Co, Tucson, AZ

The Basic program in **Listing 1** performs Quine-McCluskey minimization on a truth table. After commanding the program to RUN, enter the number of variables per truth-table entry. Then enter the total of true truth-table entries plus the number of don't-care truth-table entries.

Lastly, punch in the truth-table entries themselves.

Listing 1—Quine-McClusky truth-table-reducing program

```
100 KEY OFF
110 '=====  QUINE-McCLUSKEY LOGIC MINIMIZATION  =====
120 '=====  by Earles L. McCaul.......07/17/88  =====
130 DIM F(40), F$(40), FF$(40), L$(40), U(40), W$(40)
140 DEFINT H,I,J,K,X,Y,Z
150 BANNER$="* * * * *  QUINE-McCLUSKEY LOGIC MINIMIZATION  * * * * *"
160 CLS : PRINT BANNER$ : PRINT""
170 '----- INPUT LOGIC VARIABLES -------------------------------------------
180 INPUT"* *  How many BITS (variables) wide";B : PRINT""
190 INPUT"* *  How many VALID/DON'T CARE combinations";N : NN=N : C=N : PRINT""
200 PRINT"* *  Enter VALID/DON'T CARE combinations in descending order..."
210 PRINT"     NOTE: add suffix 'x' for DONT'T CARES (ie, 101x):"
220 FOR I=1 TO N : PRINT"      f(";I;") = "; : INPUT F$(I) : NEXT I
230 '----- VERIFY/CORRECT INPUTS -------------------------------------------
```

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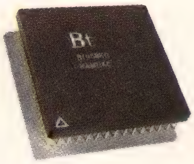

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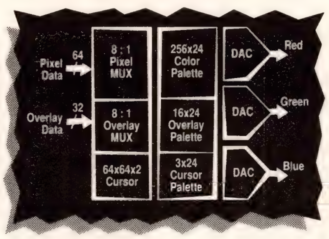

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CIRCLE NO. 149

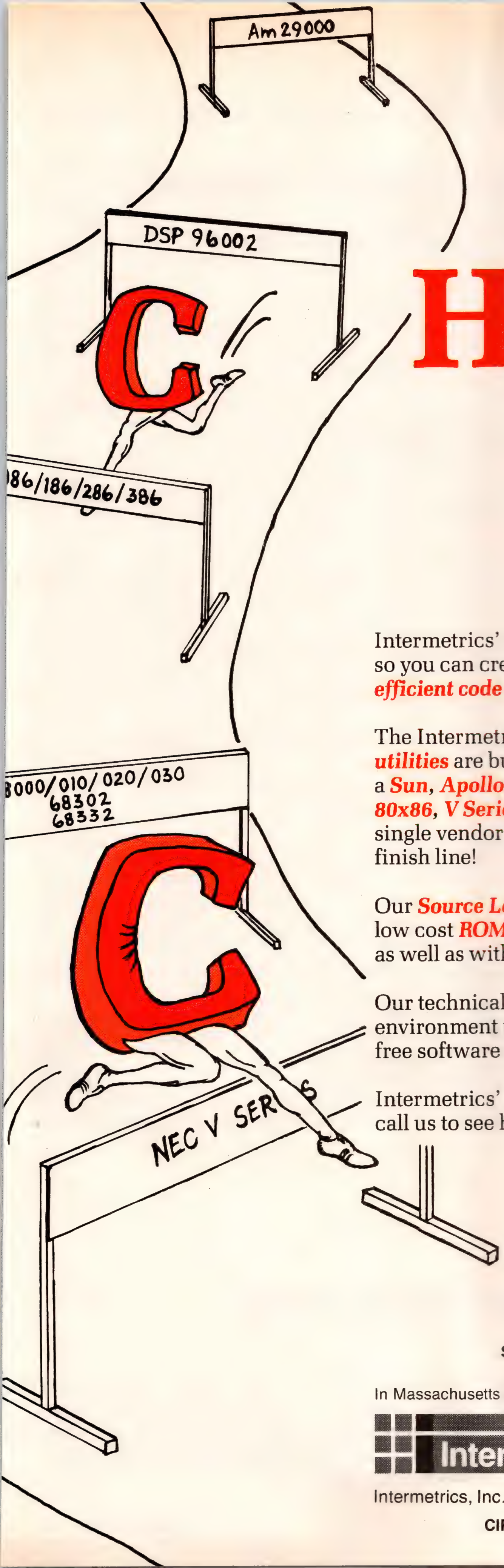
Do not enter them in numerical order. You must group your truth-table entries by the total number of true values per entry. Enter the group having the largest number of true entries first, and the remaining groups in descending order. After each don't-care table entry, enter an "x" or an "X". The end of the **listing** shows an example of this somewhat complex entry method.

The program will print out your truth table's prime implicants and a prime-implicant table. **EDN**

To Vote For This Design, Circle No. 748

Listing 1—Quine-McClusky truth-table-reducing program *(continued)*

```
240 CLS : PRINT BANNER$ : PRINT""
250 PRINT"* *  The VALID/DON'T CARE combinataions, f(x) are:"
260 FOR I=1 TO N : PRINT"    f(";I;") = ";F$(I) : NEXT I : PRINT""
270 PRINT"* *  Are these correct...<Y>es or <N>o"
280 AN$=INKEY$:IF AN$="" THEN 280
290     IF AN$="Y" OR AN$="y" THEN GOTO 320
300     IF AN$="N" OR AN$="n" THEN INPUT"* *  Which f(?) to correct";X : PRINT"
    f(";X;") = "; : INPUT F$(X) : GOTO 230
310     BEEP : GOTO 280
320 '----- COPY INPUTS INTO ARRAYS ----------------------------------------
330 FOR H=1 TO N
340     FOR I=1 TO B : L$(H)=L$(H)+(MID$(F$(H),I,1)) : NEXT I
350 NEXT H
360 NX=0
370 FOR I=1 TO N
380     IF LEN(F$(I))=B THEN NX=NX+1 ELSE 400
390     FF$(NX)=F$(I)
400 NEXT I
410 '----- IF LINES >80 SET PRINTER TO COMPRESSED MODE ----------------------
420 LL=(((NX+1)*(B+1))+1)
430 IF LL=>80 THEN LPRINT CHR$(15) : WIDTH "LPT1:",132
440 LPRINT BANNER$ : LPRINT""
450 '----- ASCII-to-NUMERIC -------------------------------------------------
460 FOR I=1 TO N : XX=0
470     FOR J=1 TO B
480         X=ASC(MID$(F$(I),J,1))-48 : IF X<0 THEN X=0
490         XX=XX+X : F(I)=XX
500     NEXT J
510 NEXT I
520 '----- PRINT COMBINATIONS & NUMBER OF 1's -------------------------------
530 FOR I=1 TO N : LPRINT"     f(";I;") = ";F$(I);"  ";F(I) : NEXT I : LPRINT""
540 '----- PERFORM COMPARISONS and MINIMIZATIONS ----------------------------
550 FOR I=1 TO N : U(I)=0 : NEXT I
560 N=C : C=0 : ZT=0
570 FOR H=1 TO N
580     FOR I=(H+1) TO N : ZZ=0 : T$=""
590         IF F(H)-F(I)<>1 THEN GOTO 670
600         FOR J=1 TO B
610             X$=MID$(L$(H),J,1) : X=ASC(X$)-48
620             Y$=MID$(L$(I),J,1) : Y=ASC(Y$)-48 : Z=ABS(Y-X)
630             ZZ=ZZ+Z
640             IF Z=1 AND ZZ=1 THEN T$=T$+"-" ELSE T$=T$+Y$
650         NEXT J
660         IF ZZ<=1 THEN C=C+1 : W$(C)=T$ : U(H)=U(H)+1 : U(I)=U(I)+1 :ZT=ZT+1
670     NEXT I
680     IF U(H)=0 THEN C=C+1 : W$(C)=L$(H)
690 NEXT H
700 PRINT" ";ZT;" Minimizations this pass..."
710 FOR I=1 TO C : L$(I)=W$(I) : NEXT I
720 '----- ASCII-to-NUMERIC -------------------------------------------------
730 FOR I=1 TO C : XX=0
740     FOR J=1 TO B
750         X=ASC(MID$(L$(I),J,1))-48 : IF X<0 THEN X=0
760         XX=XX+X : F(I)=XX
770     NEXT J
780 NEXT I
790 IF ZT<>0 THEN GOTO 550
800 '===== PRIME-IMPLICANTS =================================================
810  PRINT"" :  PRINT"* *  The PRIME-IMPLICANTS are:"
820 LPRINT"" : LPRINT"* *  The PRIME-IMPLICANTS are:"
830 CC=0
840 FOR I=1 TO C
850     M=0
860     FOR J=(I+1) TO C
870         IF L$(I)=L$(J) THEN M=1
880     NEXT J
890     IF M=0 THEN CC=CC+1 : F$(CC)=L$(I)
900 NEXT I
910 FOR I=1 TO CC :  PRINT"     PI(";I;") = ";F$(I) : NEXT I : PRINT""
```



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CIRCLE NO. 130

Listing 1—Quine-McClusky truth-table-reducing program *(continued)*

```
920 FOR I=1 TO CC : LPRINT"     PI(";I;") = ";F$(I) : NEXT I : LPRINT""
930 '===== PRIME-IMPLICANT TABLE ===========================================
940 LPRINT"* *  PRIME-IMPLICANT Table:" : LPRINT""
950 FOR I=1 TO LL : LPRINT"="; : NEXT I : LPRINT""
960 FOR H=1 TO CC
970     LPRINT F$(H);" | ";
980     FOR I=1 TO NX
990         M=0 : Z$=""
1000        FOR J=1 TO B
1010            X=ASC(MID$( F$(H),J,1))-48
1020            Y=ASC(MID$(FF$(I),J,1))-48
1030            IF X<>(-3) AND X<>Y THEN M=M+1
1040        NEXT J
1050        IF M=0 THEN LPRINT FF$(I); ELSE FOR K=1 TO B : LPRINT "-"; : NEXT
1060        LPRINT" ";
1070    NEXT I
1080    LPRINT""
1090 NEXT H
1100 FOR I=1 TO LL : LPRINT"="; : NEXT I : LPRINT""
1110 END
```

```
* * * * *  QUINE-McCLUSKEY LOGIC MINIMIZATION  * * * * *

     f( 1 ) = 1111   4
     f( 2 ) = 1101X   3
     f( 3 ) = 1011   3
     f( 4 ) = 0111   3
     f( 5 ) = 1010   2
     f( 6 ) = 1001   2
     f( 7 ) = 0011   2
     f( 8 ) = 1000   1
     f( 9 ) = 0100   1
     f( 10 ) = 0001   1
     f( 11 ) = 0000X   0


* *  The PRIME-IMPLICANTS are:
     PI( 1 ) = 1--1
     PI( 2 ) = --11
     PI( 3 ) = 10--
     PI( 4 ) = -0-1
     PI( 5 ) = -00-
     PI( 6 ) = 0-00

* *  PRIME-IMPLICANT Table:

===================================================
1--1 | 1111 1011 ---- ---- 1001 ---- ---- ---- ----
--11 | 1111 1011 0111 ---- ---- 0011 ---- ---- ----
10-- | ---- 1011 ---- 1010 1001 ---- 1000 ---- ----
-0-1 | ---- 1011 ---- ---- 1001 0011 ---- ---- 0001
-00- | ---- ---- ---- ---- 1001 ---- 1000 ---- 0001
0-00 | ---- ---- ---- ---- ---- ---- ---- 0100 ----
===================================================
```

Program simplifies Boolean expressions

Dai Jin Kun
Tianjin Institute of Metrological Technology, Tianjin, China

The Basic program in **Listing 1** runs on IBM PCs and simplifies Boolean expressions. First, you must cast your Boolean expression in classical, canonical, minterm form. If your expression is not in minterm form, logically AND your expression with $(A + \overline{A})$, $(B + \overline{B})$, $(C + \overline{C})$, . . . , until it is.

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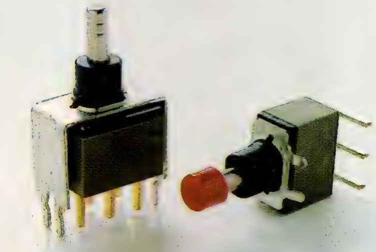

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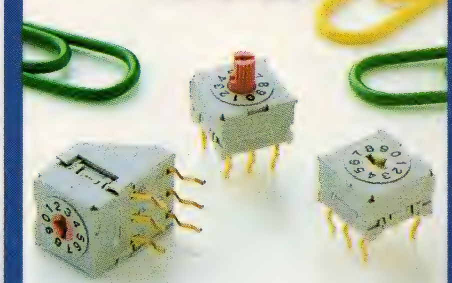

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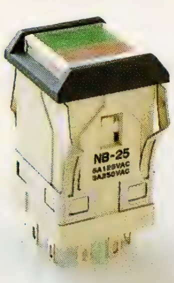
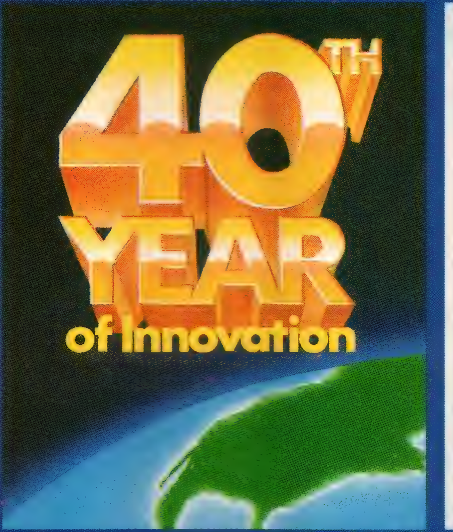
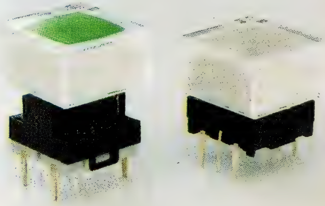


New compact, industrial-grade NB snap-in LED pushbutton with split legend up to 4 ways. Built-in resistor. Numerous options.



WORTH A MILLION



Million operations from unique LED illuminated JB keypad switch. Red, green or yellow LED options.

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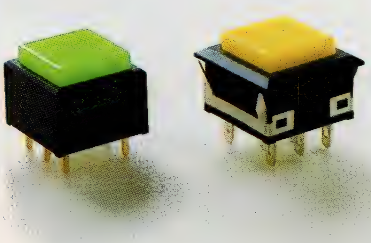

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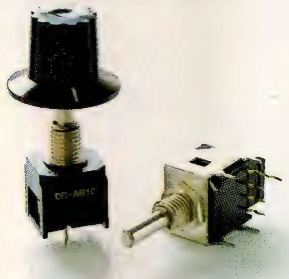

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Enter your minterms in the form of ones and zeros corresponding to the true or false assertions in each minterm. Enter a −1 after the last minterm to begin processing.

The program will print out a simplified result with asterisks, "*", substituted for terms the program completely factored out. EDN

To Vote For This Design, Circle No. 749

Listing 1—Boolean-expression-simplifying program

```
15 KEY OFF:CLS
16 LPRINT "The Simplification of Boolean Function"
18 FOR A=1 TO 38:LPRINT "-";:NEXT A
19 LPRINT
30 INPUT "Number of variables K=";K
33 IF K<=1 OR K>=10 THEN 30
39 LPRINT "Number of variables K=";K
50 M=2^(K+2)
60 DIM A$(M),B$(M),A(M)
70 FOR I=1 TO K
80 E$=E$+"*"
90 NEXT I
100 N=0:T=1
110 PRINT "Enter minterms"
111 LPRINT "Minterms are:"
120 PRINT "Input ends when -1 is entered"
150 PRINT TAB(7);"X$=";:INPUT X$
160 IF X$="-1" THEN  LPRINT :GOTO 240
166 LPRINT TAB(15);"(";N+1;")";TAB(21);X$
170 IF LEN(X$)<>K THEN PRINT "Error in bits":GOTO 150
180 FOR I=1 TO K
190 P=VAL(MID$(X$,I,1))
200 IF P<>0 AND P<>1 THEN PRINT "Error in number systems":GOTO 150
210 NEXT I
220 N=N+1
230 A$(N)=X$:GOTO 150
240 IF N<=1 THEN 930
250 FOR I=1 TO N-1
260 IF A$(I)=" " THEN A(I)=1:GOTO 460
270 FOR J=I+1 TO N
280 IF A$(J)=" " THEN A$(J)=" ":A(J)=1:GOTO 450
290 IF A$(I)=A$(J) THEN A$(J)=" ":A(J)=1:GOTO 450
300 FOR S=1 TO K
310 R$=MID$(A$(I),S,1)
320 T$=MID$(A$(J),S,1)
330 IF R$=T$ THEN 350
340 U=S:GOTO 360
350 E=E+1
360 NEXT S
370 IF E<K-1 THEN E=0:GOTO 450
380 L1=L1+1:E=0
390 IF U=1 THEN 420
400 IF U=K THEN 430
410 B$(L1)=LEFT$(A$(J),U-1)+"*"+RIGHT$(A$(J),K-U):GOTO 440
420 B$(L1)="*"+RIGHT$(A$(J),K-U):GOTO 440
430 B$(L1)=LEFT$(A$(J),U-1)+"*":GOTO 440
440 A(I)=1:A(J)=1
450 NEXT J
460 NEXT I
480 IF L1=0 THEN LPRINT "F=";:GOTO 620
500 FOR J=1 TO N
510 IF A(J)=1 THEN 540
520 L1=L1+1
530 B$(L1)=A$(J)
540 NEXT J
550 N=L1:L1=0
560 FOR I=1 TO N
570 A(I)=0
580 A$(I)=B$(I)
590 NEXT I
600 PRINT :T=T+1
610 GOTO 250
620 FOR S1=1 TO K
630 FOR I=1 TO N
640 IF A$(I)=" " THEN 880
```

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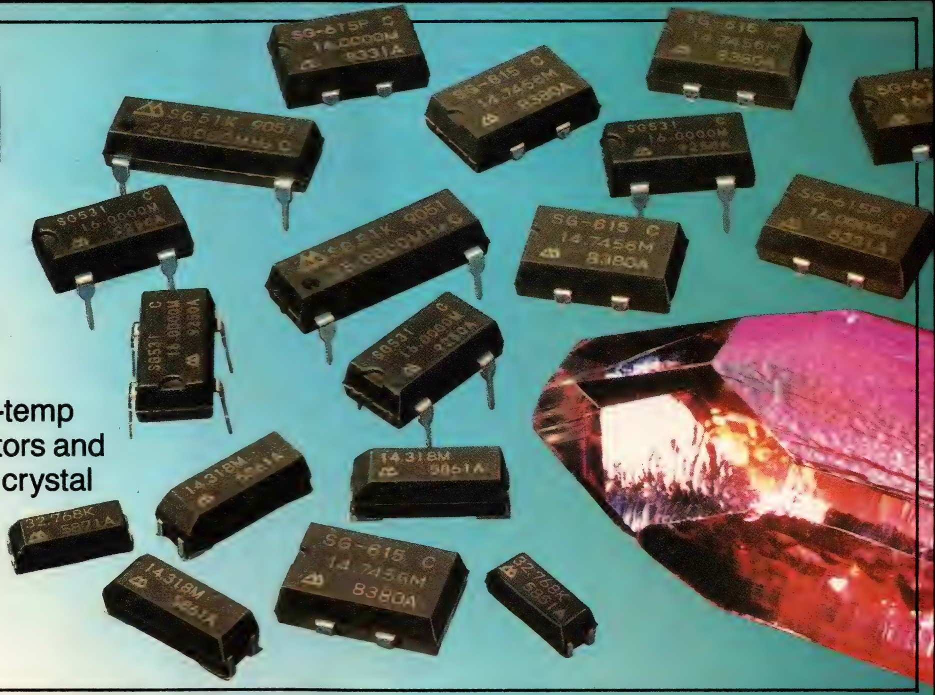

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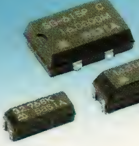

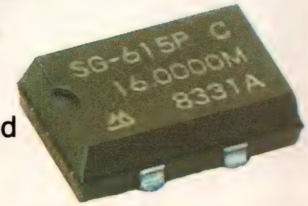

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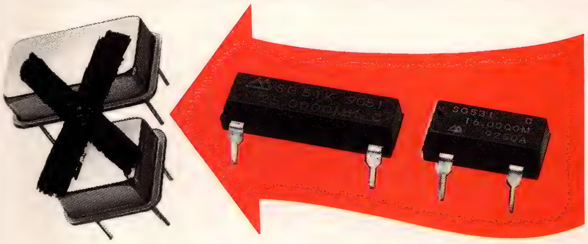

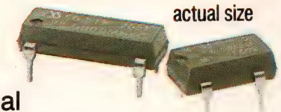

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CIRCLE NO. 170

Listing 1—Boolean-expression-simplifying program *(continued)*

```
650 FOR J=1 TO N
660 IF J=I THEN 870
670 IF A$(J)=" " THEN 870
680 FOR S=1 TO K
690 IF S=S1 THEN 860
700 P$=MID$(A$(I),S,1):Q$=MID$(A$(J),S,1)
710 IF P$="*" THEN 860
720 IF Q$="*" THEN 860
730 IF P$=Q$ THEN 860
735 FOR E=1 TO N
750 IF E=I OR E=J THEN 850
760 R$=MID$(A$(E),S,1)
770 IF R$<>"*" THEN 850
780 FOR F=1 TO K
790 IF F=S THEN 830
800 P$=MID$(A$(I),F,1):Q$=MID$(A$(J),F,1):R$=MID$(A$(E),F,1)
810 IF R$=P$ AND R$=Q$ OR R$=P$ AND Q$="*" OR R$=Q$ AND P$="*" THEN 830
820 GOTO 850
830 NEXT F
840 A$(E)=" ":A(E)=1
850 NEXT E
860 NEXT S
870 NEXT J
880 NEXT I
890 NEXT S1
900 FOR I=1 TO N
910 B$(I)=" "
920 NEXT I
930 FOR I=1 TO N
940 IF A(I)= 1 THEN 970
950 L1=L1+1
960 B$(L1)=A$(I)
970 NEXT I
980 FOR I=1 TO N-1
990 IF B$(I)=E$ THEN 1100
1000 IF B$(I)=" " THEN 1070
1010 FOR J=I+1 TO N
1020 IF B$(J)=" " THEN 1040
1030 IF B$(I)=B$(J) THEN B$(J)=" "
1040 NEXT J
1050 IF I=1 THEN LPRINT "("B$(I)")";:GOTO 1070
1060 LPRINT "+("B$(I)")";
1070 NEXT I
1080 IF B$(I)<>" " THEN LPRINT "+("B$(I)")"
1088 LPRINT
1090 GOTO 1110
1100 LPRINT "1"
1110 END
```

Calculators convert numbers

Nevitt Reesor
Woodward Governor Co, Fort Collins, CO

The calculator programs in **Listing 1** run on Hewlett-Packard calculators such as the models HP28 and HP48. The routines convert a real number into a 32-bit floating-point number and vice versa. The format for the floating-point number complies with the IEEE standard. The standard specifies that the first bit of the floating-point number is the sign bit, followed by 8 bits of exponent (offset by 127), with the remaining 23 bits being the fractional mantissa.

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Design Ideas continued on pg 246

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Listing 1—Floating-point-conversion calculator routines

```
Real to floating-point:

(The floating-point number will emerge in 32-bit hex format, i.e.,
 with a "#" prefix.)

<<
    HEX 32 STWS                 ; Set the binary data format to 32-bit hex.
    1 CF
    DUP

    IF                          ; If the number has a value of zero it will
        0 ≠                     ; not convert properly so the conversion is
    THEN                        ; skipped and the #0h result is forced.

        DUP

        IF                      ; If the number is negative set a flag
            0 <                 ; and change it to a positive number.
        THEN
            1 SF
            NEG
        END

        0 ’PWR’ STO             ; Create a global variable and clear it.
        DUP

        IF                      ; If the number is between 0 and 1 then
            1 <                 ; multiply it repeatedly by 2 until it is
        THEN                    ; between 1 and 2.
                                ; Also increment PWR so that it reprsents
            WHILE               ; the negative exponent of the number
                DUP 1 <         ; (base 2).
            REPEAT
                2 *
                1 ’PWR’ STO+
            END

            PWR NEG ’PWR’ STO   ; Change the sign of PWR.

        ELSE                    ; If the number is greater than 2 then
                                ; divide it repeatedly by 2 until it is
            DUP                 ; between 1 and 2.
                                ; Also increment PWR so that it represents
            IF                  ; the exponent of the number (base 2).
                1.99999995 ≥    ; (The strange number is due to boundary
            THEN                ;  conditions and HP28S rounding errors.)
                WHILE
                    DUP 1.99999995 ≥
                REPEAT
                    2 /
                    1 ’PWR’ STO+
                END
            END

        END

        1 -                     ; Subtract 1 to get the fractional part.
        2 23 ^ *                ; Multiply by 2^23 for binary format.
        R->B                    ; Convert to a hex binary number.

        PWR 127 +               ; Offset the exponent by 127.
        2 23 ^ *                ; "Shift" the value into the proper bits.
        R->B OR                 ; Convert to hex and OR with fraction.

        IF                      ;If the number is negative set the high bit
            1 FS?
        THEN
            #80000000h OR
            1 CF
        END
```

Listing 1—Floating-point-conversion calculator routines *(continued)*

```
        'PWR' PURGE                     ; Delete the program variable 'PWR'.

    ELSE
        R->B
    END
>>


Floating-point to real:

(The number must be entered in binary format, i.e., with a "#" prefix.
 This may be hex, octal, or true binary.)
<<
    HEX 32 STWS                         ; Set the binary data format to 32-bit hex.
    1 CF
    DUP

    IF                                  ; If the number has a value of zero it will
        #0h ≠                           ; not convert properly so the conversion is
    THEN                                ; skipped and the 0.0 result is forced.

        DUP

        IF                              ; If the high bit is set then the number is
            RL # 1h AND B->R            ; negative so set a flag and clear the
        THEN                            ; high bit.
            1 SF
            RL
            # 1h XOR
            RR
        END

        DUP                             ; Extract the fractional part of the number
        # 7FFFFFh AND                   ; (remove the exponent).
        # 800000h +                     ; Add 2^23 (in binary) which effectively
        B->R                            ; adds 1.0 to the fractional part.

        SWAP                            ; Extract the exponent and remove the
        #FF800000h AND                  ; offset by 127.
        RRB RRB RRB RL
        # 7Fh -
        DUP

        IF                              ; If the exponent is negative then make the
            RL # 1h AND B->R            ; exponent a positive binary number
        THEN                            ; (2's complement), convert it to a real
            NOT                         ; number, and change the sign back to
            # 1h +                      ; negative.
            B->R
            NEG
        ELSE
            B->R
        END

        2 SWAP ^                        ; Calculate the base-2 power of the number
        SWAP *                          ; and multiply by the
        2 23 ^ /                        ; fractional-part-plus-one.  Divide the
                                        ; result by 2^23 for the actual real number.
        IF
            1 FS?                       ; If the original number was negative then
        THEN                            ; change the sign of the result.
            NEG
            1 CF
        END

        ELSE
            B->R
        END
>>
```

Design Entry Blank

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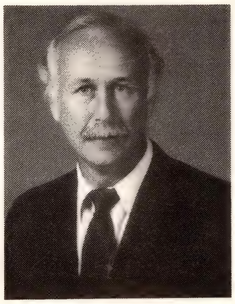

Michael Wyatt's Design Idea, "Divider displays uncanny accuracy," which appeared on pg 179 of the March 16, 1989, issue of EDN, has been selected as the best Design Idea of 1989. Wyatt will receive $1500 for his efforts.

"My wife called me at work to tell me I'd won," said Wyatt. "She was excited, my colleagues were excited, and I was excited. It's not every day you win something like this." That may be true, but winning is something that Wyatt seems to do a lot of. Last year his employer, SSAvD Honeywell Inc (Clearwater, FL), recognized his work by giving him its H W Sweatt Engineering/Science Award. The award, of which only four or five are given—worldwide—in a single year, is named after one of Honeywell's founders.

Wyatt's winning Design Idea sprang from a favorite pastime—playing "what-if" games. "I like to try to take a circuit and apply it in an unusual way," he said. "If you look at a problem from a different aspect, you'll find a solution."

The circuit that Wyatt built can be used in A/D and D/A converters, and in applications that need two supply voltages with exact ratios to each other. It divides a reference voltage in half with great accuracy, but it uses no precision components.

Wyatt is a graduate of the University of South Florida (Tampa), from which he received his BSEE. He has worked for Honeywell for 10 years and currently is a principal staff engineer in microwave communications. Wyatt has previously designed A/D and D/A converters, and he writes some of the software that he uses. He holds four patents and has three more pending.

When not designing $1500 circuits and picking up company awards for his work, Wyatt is an avid tennis player. He is a member of a local tennis club and has a United States Tennis Associtaion rating of 5.5. Top touring pros such as Ivan Lendl and John McEnroe are rated at 7.

"I play four times a week," said Wyatt. "Tennis is a great sport. It's great physically, and it takes my mind off work. I may physically leave the office at 5 or 6 pm, but I keep it with me when I walk out the door—especially when there are problems." Wyatt has proven, however, that he usually beats those problems.

—Jim Scanlan

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Keithley MetraByte and Keithley DAC manufacture the broadest range of high quality hardware in the data acquisition industry. Keithley Asyst supplies the acquisition and analysis software that works with the hardware from many manufacturers, as well as our own.

All together, Keithley MetraByte/Asyst/DAC has the answers... to hardware questions, to software questions, to application questions. And it's only one phone call away. You can reach the industry's most versatile technical support group at 508-880-3000.

And if you'd like to meet the people that can answer the questions, we offer seminars in cities nationwide. It's your chance to see how all the pieces fit together, discuss your application with an expert, and learn about the new products and support that could make your job a lot easier.

Keithley MetraByte/Asyst/DAC has it all. And, it's all in one catalog. Call 508-880-3000 and ask for your free copy.

When it comes to PC-based data acquisition and control hardware and software needs, it's all in a name. Keithley MetraByte/Asyst/DAC.

KEITHLEY METRABYTE/ASYST/DAC
PC Data Acquisition Hardware and Software

CIRCLE NO. 186

OPTREX LCDs.

One call can turn your bright new idea into reality.

The fact is, the state-of-the-art in LCDs is changing rapidly. And we at Optrex are largely responsible for that change.

So nobody knows more about LCDs and new product applications than we do. And no one can offer you stronger engineering support, better quality, higher reliability, better delivery, or better service.

The fact is, we're the largest supplier of LCDs in the world. And we're cost-competitive worldwide, too.

So if you're looking for new product support or existing product improvement in LCDs, you now know who to call:
Optrex: (313) 471-6220.

OPTREX

OPTREX
Asahi Glass/Optrex
23399 Commerce Drive
Farmington Hills, MI 48024

CIRCLE NO. 126

See Us At Electro '90 Booth #5709

Most standard analog ICs leave something to be desired.

Semi-
how to get
# of what

You're looking for an edge. Through higher integration. Or performance improvements. Or unique packaging options. Things you've always wanted from standard analog products. But couldn't get.

Until now.

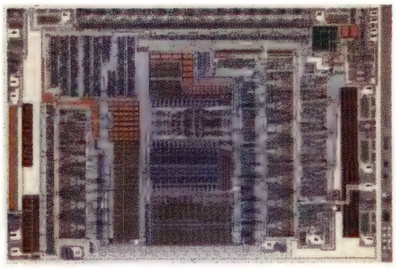
Because now there's semi-standard…a new way of thinking about analog design. One that gives you some of the rewards of analog ASIC, without many of the risks. Because you start with a standard product. If that's all you need, fine.

But if you want more—more drive current, more efficient space utilization, more system performance—semi-standard can give you that. In very little time. With minimal risk. In CMOS or bipolar processes.

Utilizing our proven ASIC tool set and design methodologies, we can enhance your standard solution by changing the functionality or performance characteristics. Or by tightening electrical, environmental or unique quality specifications. Or simply by modifying your packaging to optimize your system's requirements. And give you working bipolar prototypes in as little as 6 weeks, CMOS in as little as 12. Consider the possibilities.

The Lower, The Better.

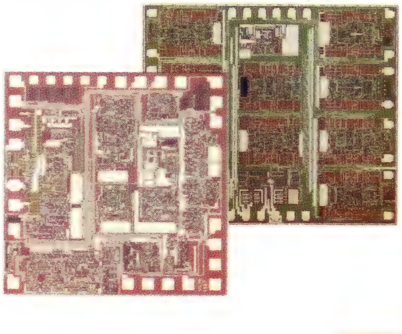
When one of our customers received a request from one of the major RBOCs to supply a telephone line equalizer with a very low group delay, we simulated the condition and simply re-wired the building blocks of one of our standard CMOS products. And delivered the goods, in less than 3 months.



standard: much more you need.

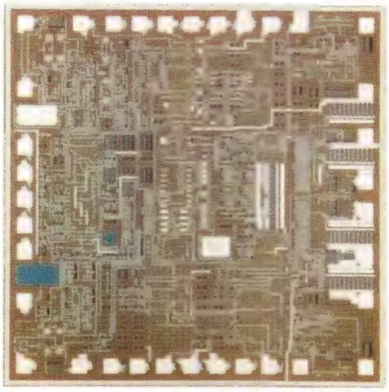
The Tighter, The Better.

By quickly and easily adding a unique trim capability to one of our standard hard disk drive servo products, we delivered a much tighter voltage reference and satisfied a major customer's critical power fail detect requirement. On time. On budget. Giving him a real competitive advantage. Responding to a number of customers' immediate needs, we also solved a system yield problem through tighter pulse pairing. By adding trim capability to our standard ML 8464C pulse detector, we were able to raise the performance specs by 200% and quickly solve their application problem.



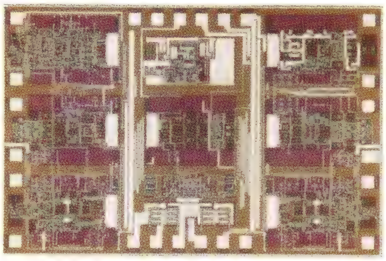
The Fewer, The Better.

When a major military supplier asked us to help solve a space problem on an advanced military radio, we used our FB 3490 tile array and existing macros to combine three 100KHz PWM controllers onto a single chip, in a single compact package. Quickly turning a standard answer into a small wonder.



The Smaller, The Better.

After evaluating our ML4621 Fiber Optic Inter-Repeater Link quantizer, three different networking companies asked us to develop smaller, lower power versions of our standard offering. The result? Two new versions, in TTL and ECL, each optimized for a particular interface, with lower pin counts and power consumption.



Micro Linear

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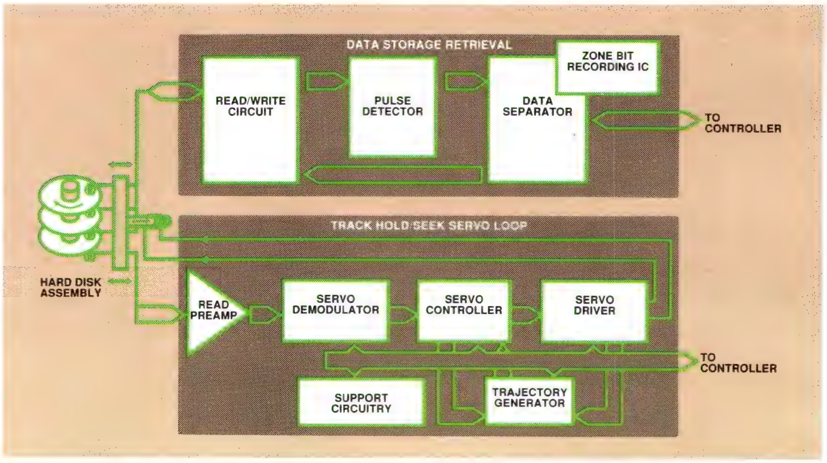
NOTES FOR DISK DRIVE DESIGNERS

How to design a strategic advantage into your next disk drive.

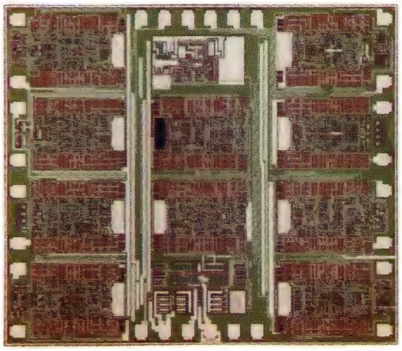


Micro Linear's full set of HDD ICs support both dedicated and embedded servo disk drives with read/write preamps, pulse detectors, phase locked oscillators and 8-bit data converters.

In the disk drive business, time to market is everything. Yet you can't be satisfied with standard read/write and servo control solutions.

What you need is semi-standard. Products with higher performance. Higher integration. Or increased functionality. That you can get in time to capitalize on narrow windows of opportunity. With a minimal amount of risk.

Semi-standard solutions like our ML8464C pulse detector, the first chip to offer a +/-1 nanosecond pulse pairing performance advantage, reducing bit error rates and increasing yields. Or our ML4041/4042 pulse detectors that combine 1ns pulse pairing with 2 μs write-to-read recovery in the industry-standard footprint.



Semi-standard solutions like the ML 4401 Servo Demodulator are based on Micro Linear's tile array technology, allowing modification of functional blocks to gain a competitive edge.

Or our ML4400 Chip Set that provides a highly integrated solution for fast-access, high TPI dedicated servo systems. It's a standard, off-the-shelf solution that's been designed with our bipolar tile-arrays. So you can start with our standard solution or modify the functional blocks to gain a competitive edge. And get working prototypes in as little as 6 weeks.

Got a high data rate drive that you want to race to market? Our new ML4025 data separator runs up to 33MB/s and is the only chip to support both RLL (1,7) and RLL (2,7) codes. Add constant density recording capability with our ML4417/4427 ZBR™ chip and you can achieve storage density advantages, with a VCO that operates over a 4:1 range up to 100 MHz.

You can even specify custom packaging options on any HDD product to satisfy critical on-board space requirements.

Want to know more about how you can gain a competitive advantage on your next drive? Just call (408) 433-5200, ext. 403, or write to:

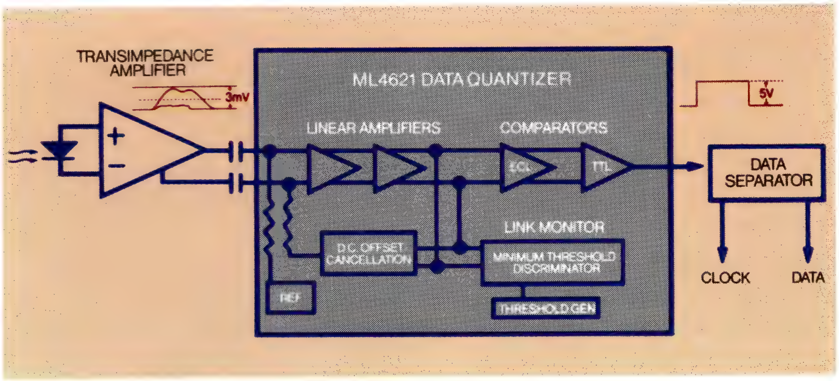
Micro Linear
Dept. HDD
2092 Concourse Drive
San Jose, CA 95131.

Micro Linear

™ZBR is a trademark of Seagate Technology Inc.

NOTES FOR ANALOG SYSTEMS DESIGNERS

Now there's a high performance single-chip solution for quantizing fiber optic signals.



ML 4621 converts Low Level Pulses from a PIN Diode Preamp into Clean Digital Signals.

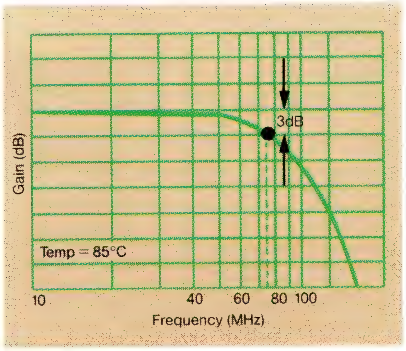
Micro Linear's ML4621 is the first complete solution for converting low-level analog pulses from a fiber optic PIN diode preamp to digital signals, enabling you to interface with the clock recovery circuit.

The ML4621 is a highly integrated high performance solution for many different types of fiber optic receivers, including IEEE 802.3 and IEEE 802.5 Local Area Networks.

High Frequency Design Made Easy

The ML4621 contains all the necessary circuitry for quantizing signals at data rates up to 100Mbaud. The chip includes a high speed comparator, wide band amplifier, a link monitor and a DC offset cancelling circuit. The high level of integration greatly simplifies the design of a fiber optic receiver by eliminating multiple discrete devices.

The ML4621 data quantizer can accept a wide dynamic range of signal strengths at its input, up to 55 dB.



ML 4621's Wide Bandwidth makes it usable to 100 MBaud

The wide dynamic range means the ML4621 can be used where combinations of high and low voltage input levels might saturate less accommodating, discrete solutions. The quantizer's low noise voltage (25μV) makes it insignificant compared to other components.

Once your data signal has gone through two cascaded stages of wideband (50MHz) gain amplification, you can choose between either a single +5V TTL comparator, or a +5V or −5.2V ECL comparator to interface with other blocks.

For minimum use of board space, two other versions, the ML4622 and ML4623, are available in smaller packages. One has only TTL outputs and the other has only ECL outputs.

Built-In Link Monitor

A user adjustable link monitor prevents incorrect data from being passed by disabling data outputs when incoming signals fall below externally set threshold levels. The circuit also transmits a status signal to the system.

Semi-Standard Versions

The ML4621 family is developed on Micro Linear's family of bipolar tile arrays. It allows easy customization to your specific applications, including the addition of blocks, such as a Fiber Optic LED driver, or a transimpedance amplifier, or changes in I/O and other packaging options.

Call Or Write For More Information

If you would like more information on the ML4621 fiber optic data quantizer, or on Micro Linear's complete line of linear devices, call (408) 433-5200, extension 900. Or write:

Micro Linear
Department Q4
2092 Concourse Drive
San Jose, CA 95131

Micro Linear

NOTES FOR POWER SUPPLY DESIGNERS

Now you have a choice for your power supply controller.

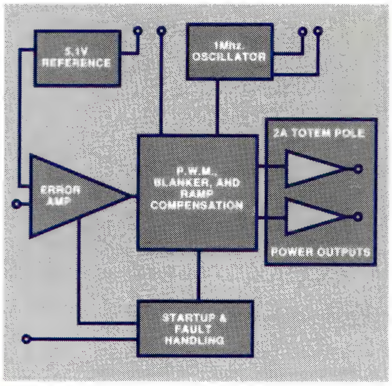
Standard devices for maximum performance.

1. Introducing three new single-chip Switch Mode Power Supply controllers that save space, money and time.

The new 16-pin ML4825 and ML4823 are improved pin-compatible replacements for the UC1825 and UC1823. A third new controller, the ML4809, is packed with extra features and functions for better stability, easier starting and synchronization.

PART TYPE	SOFT START RESET	UNDER-VOLTAGE OUTPUT STATE	COMPARATOR TO OUTPUT DELAY
ML4823 ML4825	COMPLETE	LOW	40 nS
UC1823 UC1825	PARTIAL	FLOAT	50 nS

Micro Linear/Unitrode Comparison



Micro Linear PWM Controllers Provide Maximum Performance

The ML4809 starts with all the features of the ML4825, then adds even more:

Synchronization:
- separate clock I/O pins
- wide dynamic range VCO
- toggle flip-flop output and preset inputs

Stability:
- on-chip programmable ramp compensation
- blanker to reject turn-on spike
- completely independent error ramp

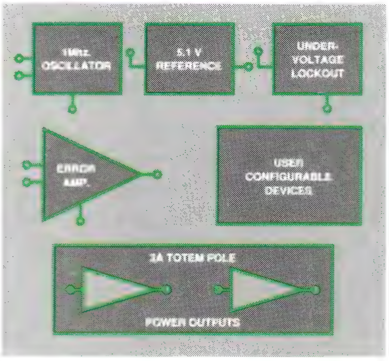
Start-up/Fault conditions:
- 7V hysteresis on under-voltage lockout
- full reset with programmable delay

If one of these new standard controllers doesn't meet your special high-frequency system needs, Micro Linear can provide a semi-standard part to your specific applications.

Semi-Standard devices for maximum flexibility.

2. Announcing the new FB3480, the first array specifically designed for high frequency Switch Mode Power Supply applications.

The FB3480 technology allows both Standard and Semi-Standard SMPS controllers to be quickly and easily developed starting from the same piece of silicon. This array contains crafted high performance "core cells" optimized to perform all the standard functions found in all PWM controllers. In addition a large area of uncommitted components on the chip can be configured to your specifications using Micro Linear's library of "soft macros." These macros implement a full complement of logic, comparator and other functions which make your controller unique. This approach allows you to evaluate the performance of the standard products then to customize a unique solution with a minimum of cost and effort, without sacrificing performance.



ML3480 Array Enables Easy Custom Design

For more information on the new single-chip standard and semi-standard SMPS controllers from Micro Linear, call (408) 433-5200, ext. 900.

Or write:
Micro Linear, Dept. PWM
2092 Concourse Drive
San Jose, CA 95131

Micro Linear

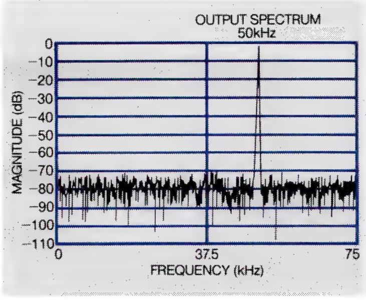
NOTES FOR ANALOG SYSTEMS DESIGNERS

New 8-bit A/D converters with sample and hold maintain accuracy at 50KHz.

The new ML2258 and ML2281 series from Micro Linear maintain true 8-bit accuracy while digitizing a 0V to 5V, 50KHz sine wave. This gives you near ideal signal-to-noise of 47dB. All devices come with either a double buffered parallel or serial digital interface. Yet, these devices are superior for interfacing to temperature, pressure and position transducers due to low cost and ease of use.

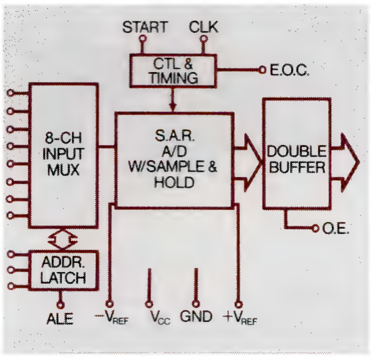
Dynamic Performance and 8-bit Guaranteed Accuracy

Dynamic performance and 6 microsecond conversion time make the ML2258 and ML2281 series ideal for signal processing as well as for digitizing sensors.



The FFT Plot of the ML2258 Converting a 50 KHz, 0 to 5V, Low Distortion Sine Wave Input.

Total unadjusted error in the ML2258 and ML2281 series is ±½ or ±1 LSB, which includes the sum of nonlinearity, full scale and zero scale errors. It is important to note that no full scale or zero adjust is required.



ML2258 Block Diagram

Designed for Ease of Use with a Choice of Analog Inputs

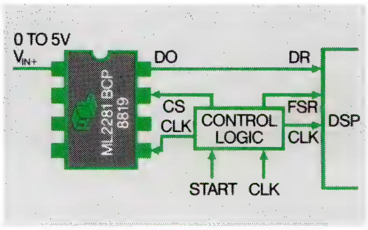
With all parameters guaranteed over the entire ambient temperature range, as well as ±10% tolerance of the single 5V power supply, the ML2258 and ML2281 series are designed for ease of use. Stable and repeatable conversions result from a digital code uncertainty of 1 mV.

Greater design flexibility is allowed by the 0V to 5V analog input range operating either ratiometrically or with a voltage reference up to 5V. The inputs are protected for up to 25mA maximum per input.

Power dissipation overall is extremely low—less than 3mA.

Digital inputs and outputs are both TTL and CMOS compatible.

The ML2258 microprocessor-compatible 8-bit A/D converter with 8 analog inputs has a double-buffered three state output and latched and decoded multiplexer address inputs. It is available in both 28-pin DIP or PCC.



ML2281 Serial DSP Interface

The ML2281 series 8-bit serial I/O A/D converters provide a serial address of the 2, 4, or 8 analog inputs. ML2281 series DIP packages are 8, 14 or 20-pin configurations. In addition, the 8-input channel ML2288 is available in a 20-pin PCC. Prices start at only $2.95 each in 100 unit quantities.

Semi-Standard Options

Customized versions of both series of converters are available to incorporate alternate packages, different specifications or slightly modified functionality.

If you would like more information on the ML2258 or ML2281 series A/D converters, or on Micro Linear's complete range of linear devices, please call (408) 433-5200, extension 912, or write:

Micro Linear
Department E/B
2092 Concourse Drive
San Jose, CA 95131

Micro Linear

Why settle for anything less?

Before you begin your next analog design, there are a number of things we think you should consider.

Should it be a standard analog IC? A semi-standard? Or even a USIC (User Specific IC)?

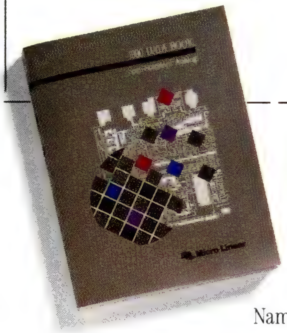
With us, the decision is yours. Because we can satisfy the whole spectrum. From high-performance standard products serving the disk drive, A/D conversion, analog telecom, power supply or local area network markets. To proprietary semi-standard solutions. To sophisticated, ASIC-based designs. Or any combination.

Since, 1983, we've pioneered the use of analog ASIC methodologies to produce high-performance, high reliability analog products for a wide range of commercial and military applications including computer peripherals, instrumentation, telecommunications, data communications equipment and military systems. Yours could be next.

To find out, simply send us your design problem with all the critical performance parameters. Our applications engineers will quickly analyze your problem, evaluate the alternatives and give you our best recommendation.

We'll even give you a number of development cost options—ranging anywhere from a one-time NRE charge to waiving it in exchange for the rights to eventually offer your design as one of our standard products.

Write to Micro Linear, 2092 Concourse Drive, San Jose CA 95131. Or send in the coupon below. Better yet, call Ken Fields at (408) 433-5200 and give him all the facts. The answers he'll give you will be anything but standard.



☐ Yes, I'd like to know more about Semi-Standard Analog. Please send me your new 1990 Data Book.

☐ Please have a Micro Linear sales engineer call me. I have an immediate requirement.

Name:__________ Title:__________

Company:__________

City:__________ State:__________ Zip:__________

Phone: ( ) __________

Micro Linear

between input and output. The IS1000 devices have transistor outputs with a current-transfer ratio (CTR) of 20 to 100%. The IS2000 devices have Darlington outputs with CTRs from 400 to 1000%. The devices come in 4-pin, 0.375×0.25×0.35-in. packages. The standard spacing between the input and output leads is 0.3 in.; a lead-form option increases this spacing to 0.59 in. IS1020 (transistor output), $1.75; IS2040 (Darlington output), $1.80 (100).

Isocom Inc, 256-H E Hamilton Ave, Campbell, CA 95008. Phone (408) 370-2212. FAX (408) 370-2309.
Circle No. 428

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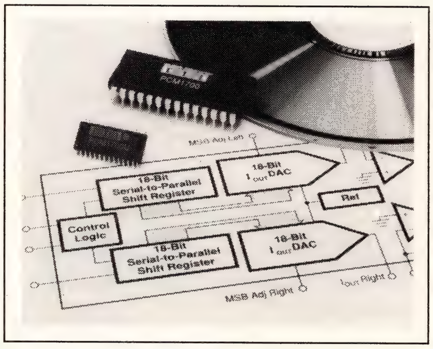
Micro Channel Interface EPLD

- *Addresses latest Micro Channel specifications*
- *Consumes 70% less supply current than earlier version*

The EPB2001 is the second generation interface erasable programmable logic device (EPLD) for the IBM PS/2 Micro Channel Architecture bus. This chip supports data transfers across the bus at 20M bytes/sec. The chip can decode addresses in 25 nsec for faster system throughput. Control-strobe timing is 18 nsec. The EPLD consumes just 30 mA of the 1.6A of the PS/2 backplane supply-current budget. In a windowed ceramic 84-pin J-lead package, $43.25; in a one-time-programmable plastic leaded chip carrier, $17 (1000).

Altera Corp, 3525 Monroe St, Santa Clara, CA 95051. Phone (408) 984-2800. **Circle No. 429**



Dual-Audio DAC

- *Samples as many as 768 kHz/channel*
- *Features 18-bit resolution*

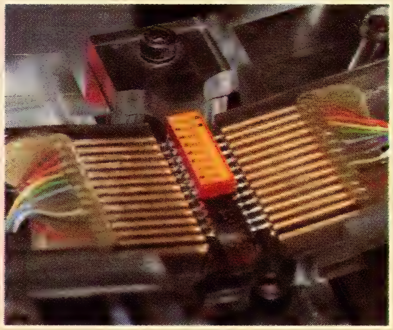
The PCM1700P dual 18-bit D/A converter samples at rates as high as 768 kHz, permitting as much as 16× oversampling of the audio spectrum. On-chip reference and control logic simplify use of the converter. Maximum THD + noise for the DAC is −92 dB, and S/N ratio measures 107 dB from 20 Hz to 20 kHz. Output settling time is 1.5 μsec for V_{out} and 300 nsec for I_{out}. Other specifications include a maxi-

Text continued on pg 268

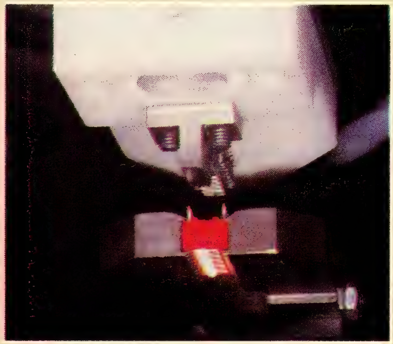
CIRCLE NO. 137

Grayhill Statistical Process Control makes DIP switch quality a reality, not a slogan

Is your DIP switch supplier being measured by SPC?



Grayhill DIP Switches are tested every step of the way in the manufacturing process. If initial contact resistance varies from control limits, the problem is immediately diagnosed and cured.



This machine automatically tests every DIP switch for actuation force. We get reliable ppm data and you get reliable DIP Switches.

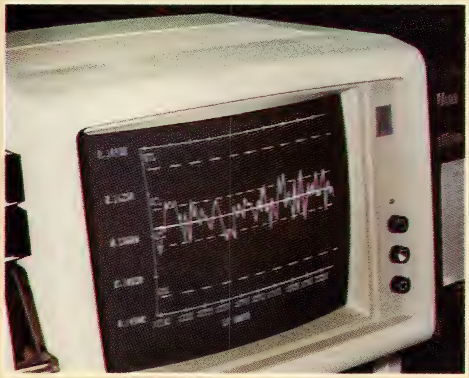
The industry's reliance on Grayhill leadership has received another boost with the implementation of SPC manufacturing techniques to our DIP switch lines. (Note: SPC data not yet available for all configurations.)

In-line measurements are control-charted. Variations are identified to maintain processes within controlled limits. Only acceptable product comes off the Grayhill line and onto yours!

If your DIP switch supplier can't give you parts per million data, you should be talking to Grayhill. We offer you the widest choice of DIP switch actuators, stations, and circuitries, including MIDIP™ machine-insertable switches. Prices are competitive, but we offer features as standard that are extras elsewhere.

Grayhill DIP switches, as well as rotary and pushbutton switches, keyboards, solid state relays and I/O modules, are available from authorized distributors world-wide and are described in detail in *EEM*.

Ask us for your FREE copy of Engineering Catalog #1 with detailed DIP switch specifications...and call now for full details on SPC DIP switches.



Variable data is entered electronically at production sites and transmitted to the Grayhill mainframe to track performance and compile reports.

Grayhill INC.

561 Hillgrove Avenue, P.O. Box 10373
LaGrange, Illinois 60525-0373 USA
Phone: (708) 354-1040 FAX: (708) 354-2820
TLX or TWX: 190254 GRAYHILL LAGE

Here's how to turn a relay with 2 changeover contacts into one with 4.

The MT4, our new relay with 4 changeover contacts, hardly occupies more board space than the MT2, our relay with 2 changeover contacts.

So if you need 6 twin changeover contacts on your board, simply install an MT2 and an MT4. Two relays of virtually identical size.

And the expensive space you formerly needed for a third MT2 is now free for other important functions.

Plus: less testing, less component cost, less assembly effort, greater reliability.

What more can you want?

(The new MT4: Power consumption at 20°C 300 mW. Temperature range −55°C to 85°C. Space occupied per contact 12 M^2.)

I'm interested in the new MT4 relay. Please send me your literature.

Company ____________________

Name ____________________

Address ____________________

____

Telephone ____________________

EDN042690

Standard Telephon und Radio AG
CH-8055 Zurich/Switzerland, Friesenbergstrasse 75

ALCATEL
STR

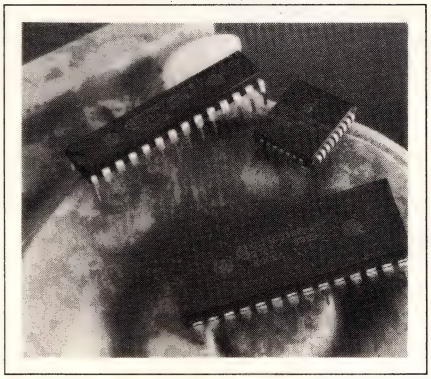
CIRCLE NO. 156

Dr. Juchli 924 STR

use in step-up, step-down, or inverting applications. The regulator features a comparator input stage that has separate pins for both the inverting and noninverting inputs. An internal 1V reference is connected to each of the comparator's inputs. Both the collector and emitter of the power-transistor switch are accessible, providing design flexibility. An external resistor sets the regulator's current limit, and an external capacitor sets its oscillator frequency, which can cover a range of 1 Hz to 100 kHz. The device comes in an 11-lead TO-220 package and operates from a supply voltage of 3.5 to 40V. $5.25 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-5856. TLX 346353.

Circle No. 426



Fast, Dual-Port FIFO

- *Specifies access time of 20 nsec*
- *Organized as 2k × 9 bits*

The KM75C03A 9-bit-wide, dual-port FIFO buffer memory can operate in systems at clock rates of approximately 40 MHz. The device features full and empty flags, and on-chip logic lets you expand the width or depth of the memory with additional chips. When used alone, the KM75C03A offers a master-reset, half-full flag, and auto-retransmit capability. The FIFO uses ring counters to track addresses, freeing you from this task. Instead, you move data in and out of the device via read/write pins. Read/write cycle time is 30 nsec. The memory consumes 120 mA when active and 15 mA in power-down mode. In 300- and 600-mil 28-pin DIPs and 32-pin plastic LCCs, $53 (1000).

Samsung Semiconductor, 3725 N First St, San Jose, CA 95134. Phone (408) 954-7272.

Circle No. 427

Optoisolators

- *Come in space-saving packages*
- *Have an input-output isolation of 11 kV*

The IS1000 and IS2000 series of optoisolators, which have a 4-mm separation between the emitter and detector, feature an 11-kV isolation

Text continued on pg 264

Score Big With Vitelic's Fast SIMMs.

Ricky SIMM rounds third. Here comes the throw from center field. SIMM dives for the plate. He scores!

Put Ricky SIMM on your main memory team and watch your high performance personal workstation score with the customer every time.

With **60** and 70ns access times, Vitelic's 256K x 36 and 512K x 36 CMOS DRAMs are the fastest SIMMs in the league. Our SIMMs are the perfect add-on memories for IBM PS/2 compatibles and advanced 386 and 486 systems. Both devices come in the standard 72 pin module.

Ricky SIMM is also available in 256K x 8 and 256K x 9 configurations in standard 30 pin SIMM and SIP modules. With access times of **60**, 70, and 80ns and fast page mode configuration, these memories are ideal for PC/workstation main memory and memory expansion.

Call Vitelic today at **800-VITELIC** to hear more about Vitelic's SIMM. Sign Ricky onto your team and watch your PCs and workstations outrun the competition.

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The Emerging Leader in Specialty Memories

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Circle 46 for literature

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If sticker price has kept you away from VME, look into Themis' new VME machine.

If your budget has you thinking about PCs, think again.

The new TSVME 110 Single Board Computer gives you the high performance VMEbus platform you want at a price competitive with the PC alternative.

Two more doors and a big back seat will only slow you down.

What you need is cost-effective VMEbus computing. That's what the TSVME 110 delivers. Under the hood it's your choice of CPUs (68000-8MHz, 68HC000-8MHz, or 68010-10MHz), with 64KB of SRAM and VMEbus IEEE 1014 compatibility, all for just $589 in quantities of 100. You couldn't build them yourself for less.

Extra features are optional.

The TSVME 110 won't load you up with costly extras. Yet, it doesn't limit your options. On-board DRAM (512KB, 1MB, or 2MB), 128KB SRAM, SCSI interface, floppy disk controller, rechargeable battery or lithium cell and a P2 connector are all available at your discretion, not ours.

No dead ends.

When you're ready for more power, we have a software and P2 compatible 68020 upgrade at an equally surprising price point. Themis also has complete VMEbus solutions for real-time processing, industrial I/O, communications, video/graphics, DSP and robotics.

So stop designing down to PC. Design up to VMEbus with the TSVME 110 Single Board Computer.

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THEMIS
COMPUTER

CIRCLE NO. 136

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☐ SURFACE-MOUNT TECHNOLOGY

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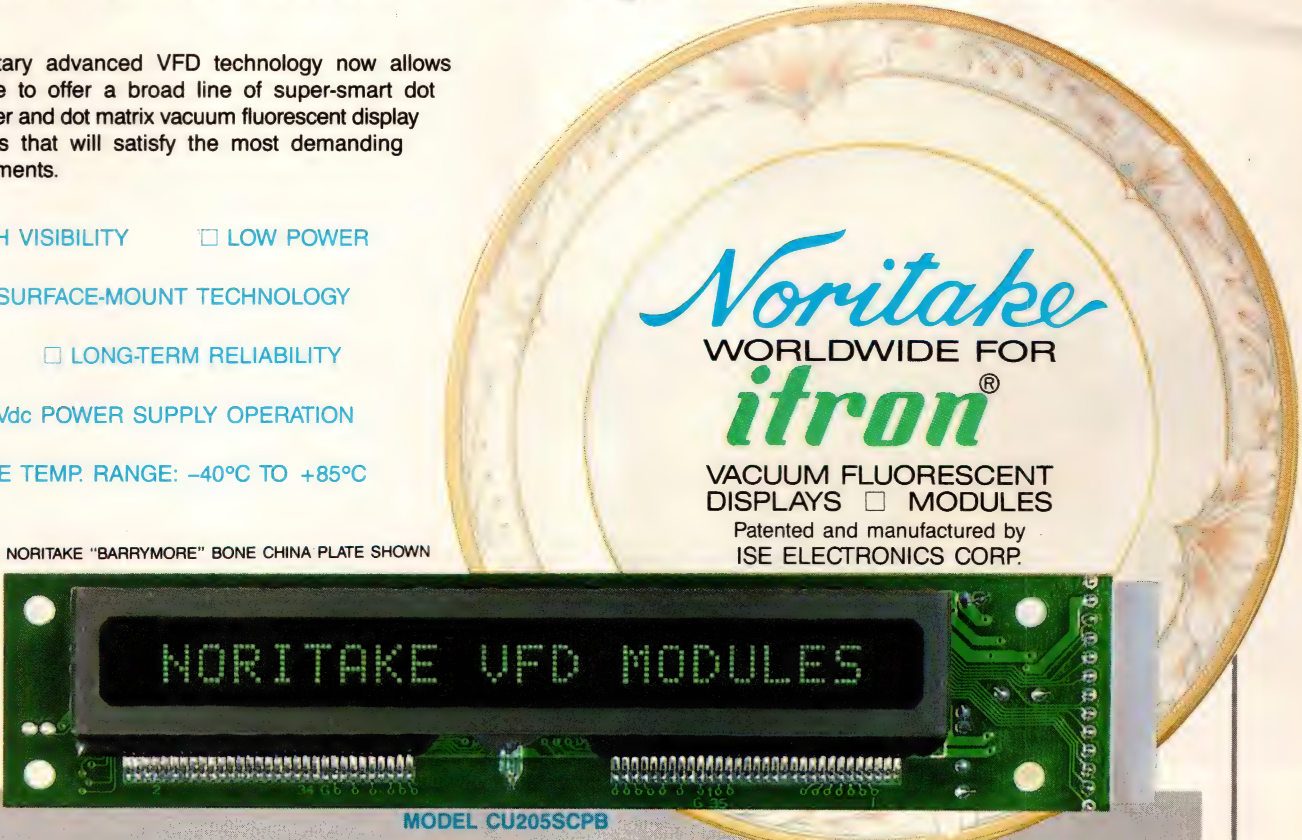
☐ WIDE TEMP. RANGE: –40°C TO +85°C



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NORITAKE "BARRYMORE" BONE CHINA PLATE SHOWN

MODEL CU205SCPB

DOT CHARACTER DISPLAY MODULES

CHARACTER FORMAT	MODEL NUMBER	NUMBER OF CHARACTERS	CHARACTER HEIGHT (MM)	INPUT (SERIAL/ PARALLEL)	BI-DIRECT BUS	* WIDE TEMP. RANGE MODELS
5 × 7 DOT MATRIX	CU165SCPB-S	1 × 16	5.0	S/P		
	CU169SCPB-L	1 × 16	9.0	P	x	
	CU205SCPB-S	1 × 20	5.0	S/P		
	CU209SCPB-L	1 × 20	9.2	P	x	
	CU2015SCPB-L	1 × 20	15.1	P	x	
5 x 7 DOT MATRIX PLUS CURSOR	CU406SCPB-S	1 × 40	5.0	P	x	
	CU20026SCPB-S	2 × 20	5.1	P	x	x
	CU40026SCPB-S	2 × 40	5.0	P	x	x
	CU40046MCPB-S	4 × 40	5.0	S/P	x	x
	CU40066MCPB-S	6 × 40	5.0	S/P	x	x
	CU40086MCPB-S	8 × 40	5.0	P	x	x

*OPTIONAL

DOT MATRIX DISPLAY MODULES

DOT MATRIX FORMAT (DOTS/LINE × NO. OF LINES)	MODEL NUMBER	NO. OF LINES AND CHARACTERS/LINE (5x7 DOT CONFIGURATION)	GRAPHICS CAPABILITY
192 × 16 (3072 DOTS TOTAL)	GU192X16	2 × 32	YES
256 × 16 (4096 DOTS TOTAL)	GU256X16	2 × 42	YES
256 × 64 (16,384 DOTS TOTAL)	GU256X64	8 × 42	YES

The models shown are typical of the broad selection available on an immediate delivery basis. Contact our nearest sales office or representative for counsel on the best Noritake VFD for your application, as well as for details on costs, custom designs, deliveries, etc.

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1-36 Noritake Shinmachi, 3 Chome, Nishi-Ku, Nagoya, Japan
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- ☐ IDEAL FOR SURFACE MOUNT AND HYBRID CIRCUITS
- ☐ UP TO 12-LAYER THICK GEOMETRIES
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- ☐ HIGH DENSITY FINE-LINE METALLIZATION

NEW NORITAKE "ICON" BONE CHINA PLATE SHOWN

METALLIZATIONS: Cu, AgPd, PtAg, Au, and Au Resinate

FINE-LINE DEPOSITION GEOMETRIES:
Lines and spaces can be configured up to 1.2 mils wide.

MULTILAYER GEOMETRIES: Up to 12 layers thick

GENERAL CAPABILITIES

	ITEM	SPECIFICATIONS		CONDITIONS
CONDUCTOR	CONDUCTOR RESISTANCE	AgPd . . . . 15-50mΩ/□ AgPt . . . . 2-4mΩ/□ Au . . . . 2-4mΩ/□		—
	ADHESION	≥2.5 KGS — INITIALLY		0.6 COPPER WIRE COVERED WITH SN 2MM □ PAD
	SOLDER LEACH RESISTANCE	≥2.0 KGS AFTER AGING (@150°C, 48 HRS.)		62 SN/Pd/2 Ag SOLDER
	ITEM	**STANDARD**	**MAX. AVAIL.**	**CONDITIONS**
RESISTOR	RESISTOR VALUE	10Ω-2MΩ	20mΩ-20MΩ	—
	TCR	±250 PPM /°C	±100 PPM/°C	—
	TRACKING TCR	±100 PPM/°C	±10 PPM/°C	—
	LOAD WATTAGE	150mW/MM²	—	—
	RESISTOR TOLERANCE	> ±1.0%	+0.3%	—
	STABILITY: TEMPERATURE HUMIDITY HEAT CYCLE HIGH TEMP. STORAGE	≤ ±1.5% ≤ ±2.0% ≤ ±2.0% ≤ ±1.5%	— — — —	430°C, 5 MIN. 60°C, 95% 125°C↔−40°C (10 CYCLES) 125°C, 1000 HRS.
INS.	INSULATION RESISTANCE	≥100MΩ	—	—

REPRESENTATIVES

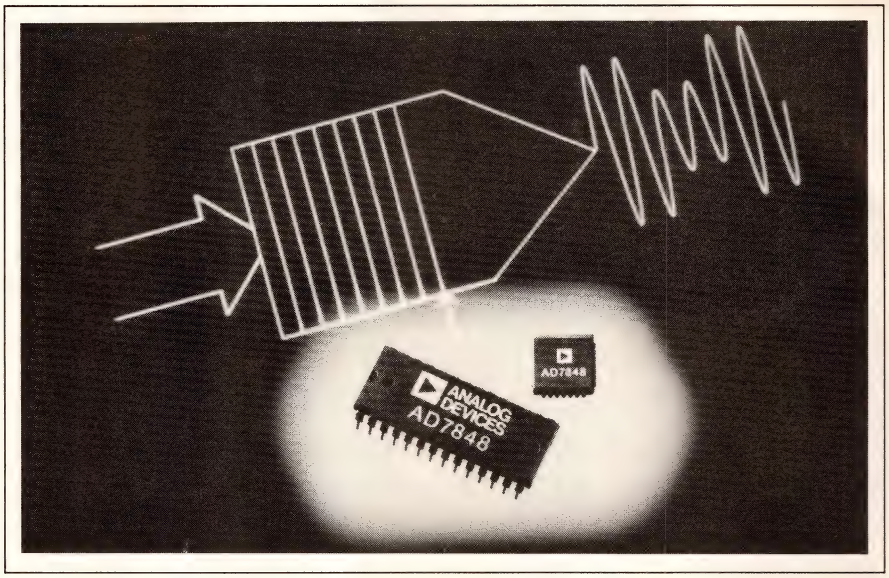
WA, OR: (503) 684-1671 ☐ Components West, Inc. **No. CA, NV:** (415) 961-1422 ☐ Westech Sales **So. CA:** SD (619) 292-1771 / OC (714) 891-4621 ☐ ELSCO **TX, OK, AR, LA:** (214) 386-4888 ☐ Norcom, Inc. **CO, UT:** (303) 794-4684 ☐ MRC **OH, WV, W. PA, KY:** (216) 461-6161 ☐ Arthur H. Baier **No. IL, So. WI:** (312) 439-9810 ☐ Coombs Asso., Inc. **AL, GA, MS, TN:** (205) 533-1730 ☐ Interep Asso. **IN:** (317) 844-4842 ☐ Fred A. Dorsey & Asso., Inc. **No. WI, MN, No. IA, ND, SD:** (612) 536-9512 ☐ Tech. Components **N.E.:** (508) 788-0316 ☐ Int. Mktg. Group **PA, MD, DE:** (215) 233-0333 ☐ C.H. Newsom & Associates **FL, Puerto Rico:** (407) 831-8233 ☐ Semtronic Asso., Inc. **NY, NJ:** (201) 376-3324 ☐ F.F. Sylvester Asso. **VA:** (804) 740-0063 ☐ Glasscock Asso. **NC, SC:** (919) 782-8100 ☐ C-Tech Sales Co. **CANADA:** (416) 671-8111 ☐ Gidden Morton Associates

FOR IMMEDIATE NEED: Circle 40   **FOR REFERENCE ONLY:** Circle 41

INTEGRATED CIRCUITS

12-Bit DAC With Internal FIFO

- *Loads data in a single operation*
- *Typical THD is −80 dB*



Featuring an 8-word-deep on-chip FIFO, the AD7848 12-bit DAC permits the loading of output data words in a single data-transfer operation. With a 42-nsec min write-pulse width, the DAC can connect directly with most high-speed DSPs, eliminating the need for external wait-state logic. A 4-μsec max settling time and a 250-kHz output update rate make the DAC suitable for audio-bandwidth voice-band modems and servo control applications. An on-chip status/control register permits the user to program the word at which the FIFO generates an "almost empty" interrupt. The DAC offers ±½-LSB relative accuracy, ±½-LSB differential nonlinearity, and ±4-LSB full-scale error. Other specifications include THD of −80 dB and a signal-to-noise ratio of 72 dB. The AD7848 generates a ±3V bipolar output signal and operates from a ±5V supply. Package options include a 28-pin DIP and a 40-pin plastic leaded chip carrier. $9.85 to $38.55 (100).

Analog Devices, 181 Ballardvale St, Wilmington, MA 01887. Phone (508) 658-9400. **Circle No. 423**

8-Bit Single-Chip Microcontroller

- *32k-byte EEPROM on chip*
- *Uses 2-level memory protection to prevent software piracy*

The 87C51FC microcontroller is pin compatible with other versions of the vendor's MCS-51 family; it doubles the memory capacity of the preceding version. In addition to a 32k-byte EEPROM, the 87C51FC provides a 256-byte RAM; three 16-bit timer/counters; and a programmable counter array with high-speed I/O, compare/capture, PWM, and a watchdog timer. A memory protection scheme, consisting of two program lock bits and a 32-bit encryption table, guards your software from piracy. The microcontroller offers a 64k-byte external program-memory space. You can develop your applications using the range of MCS-51 development tools. Packaging options include 40-lead plastic or ceramic DIPs and 44-lead plastic LCCs. Samples are available now; production quantities are scheduled for the second half of 1990. 12-MHz version, $67; 16-MHz version, $73 (1000).

Intel Corp, Literature Dept LP-53, Box 58065, Santa Clara, CA 95052. Phone (800) 548-4725. **Circle No. 424**

Sample-And-Hold Amplifier

- *Has 16-bit accuracy*
- *Acquisition time is 250 nsec*

Featuring 16-bit accuracy and acquisition times of 250 and 350 nsec to 0.0015% for 10 and 20V steps, respectively, the SP9760 is targeted for use with fast 14- to 16-bit A/D converters. The hybrid sample-and-hold amplifier offers a linearity of 0.001% for a ±10V range and of 0.0005% for a ±5V range. Other specifications include feedthrough of −103 dB, a slew rate of 120V/μsec, and a small-signal bandwidth of 30 MHz. Faithful sampling of the input signal is ensured by the low distortion of −90 dB for 5V p-p at 100 kHz and −88 dB for 20V p-p at 10 kHz. Gain error is 0.03%, offset error is 1 mV, input impedance is 100 MΩ, and the noninverting gain is unity. The SP9760 accepts both unipolar and bipolar input signals and operates from ±15V supplies. From $199 (100).

Sipex Corp, 6 Fortune Dr, Billerica, MA 01821. Phone (508) 663-9691. FAX (508) 670-9001. **Circle No. 425**

3A Switching Regulator

- *Has step-up and step-down capabilities*
- *Features an internal reference*

The latest member of the company's switching regulator family, the LM2579 is a 3A device that you can

Text continued on pg 261

UNIVERSAL PROGRAMMER

PROGRAMS

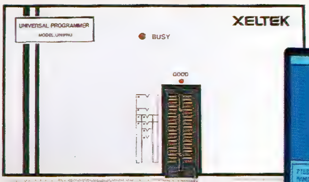
- **E(E)PROMs** upto 4Mbits & 16bit wide.
- **PALs** from AMD, ATMEL, TI, SAMSUNG & CYPRESS.
- **EPLDs** from ALTERA, INTEL, TI.
- **GALs** from LATTICE, SGS & NS.
- **FPLs** from SIGNETICs.
- **PEELs** from ICT, HYUNDAI & GOULD.
- **BIPOLAR** PROMS.
- **Micro Controllers**(8748, 8751 & 87C51 series)

SUPPORTS

- 32bit WORDSPLIT with 4 GANG adaptor.
- PALASM2/CUPL/ABEL/TANGO/OrCAD JEDEC files.
- PAL VERIFICATION using TEST VECTOR.
- GAL electronic signature recognition.
- 87C451, 87C751, 63701 X/Y/V & 63705V with adaptor(option).
- Tests ICs(TTL, CMOS) & memory ICs with user definable test patterns.

OPTIONS

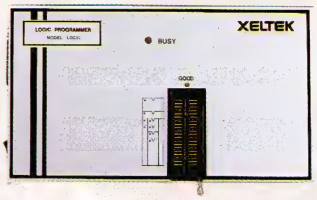
- ADAPTORs for PLCC, LCC, SOIC, FLATPAK-type ICs.
- 4 Socket Adaptor for E(E) PRom.
- Socket Adaptors for Micro Controllers.



$585 Complete*

*** Package includes software, programming module, high speed interface card, & cable.**

LOGIC PROGRAMMER



$395

PROGRAMS

PAL, GAL,
FPL, PEEL, EPLD.

- **Pull-down menu driven software.**
- **Supports user's electronic signature and manufacturer's electroinc signature**

Tango™ PLD Design Tool $495

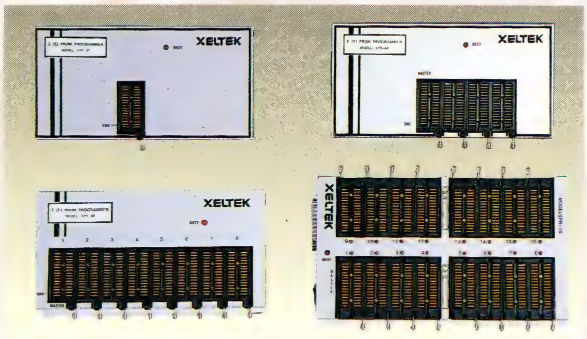
Tango-PLD is a universal tool programmable logic devices(PLDs). From its innovative approach to PLD design to its blazing compilation speed, Tango-PLD has been engineered to help you create high-quality designs in less time.

- Allows logic design and simulation before selecting a device.
- Clear, concise design language features C-like syntax.
- Optimized for fast compilation, minimization and simulation.
- Uses the industry-standard ESPRESSO logic minimizer.
- Extensive device library supports PALs, PLAs, GALs, and PEELs.

E(E)PROM PROGRAMMERS

EPR-01
$150

EPR-04
$215



EPR-08
$295

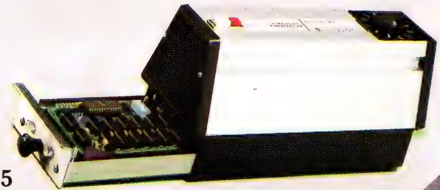
EPR-16
$595

- Programs 16K-1024K EPROM, CMOS etc.
- 1, 4, 8, 16 Gang programmers.
- High or low byte programming.

EPROM ERASER

- **QET-140 $295**
  - Erases any EPROM in just 4 seconds.
  - High intensity

- **ET-140 $95**
  - Erases upto 9EPROMs



- **ET-265 $285**
  - High capacity.
  - Erases upto 30 EPROMs W/timer.

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for PC/XT/AT/386

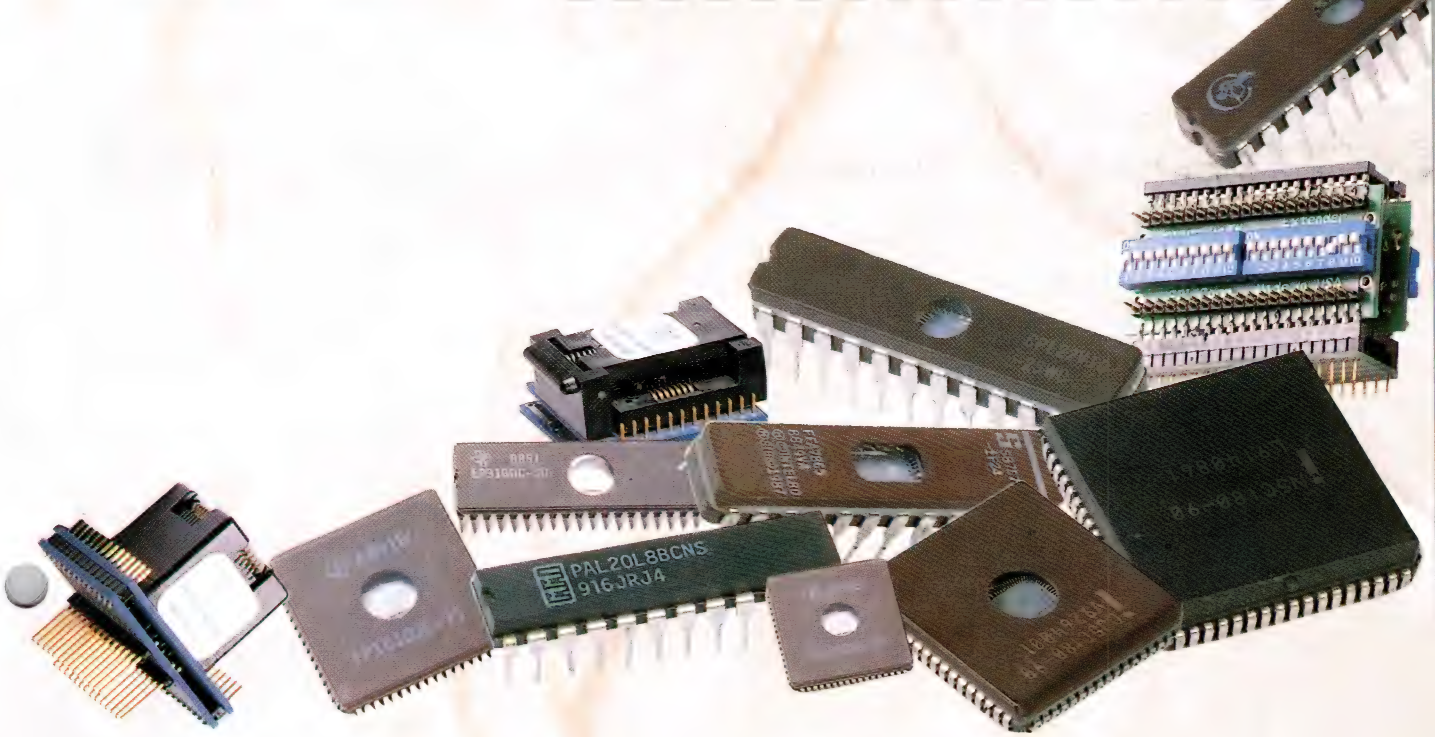
```
FILENAME     : 22V10.JED
MANUFACTURER : ICT
DEVICE TYPE  : PEEL273
CHECKSUM     : 0000
BLOW COUNT   : 0000
```

Programming functions

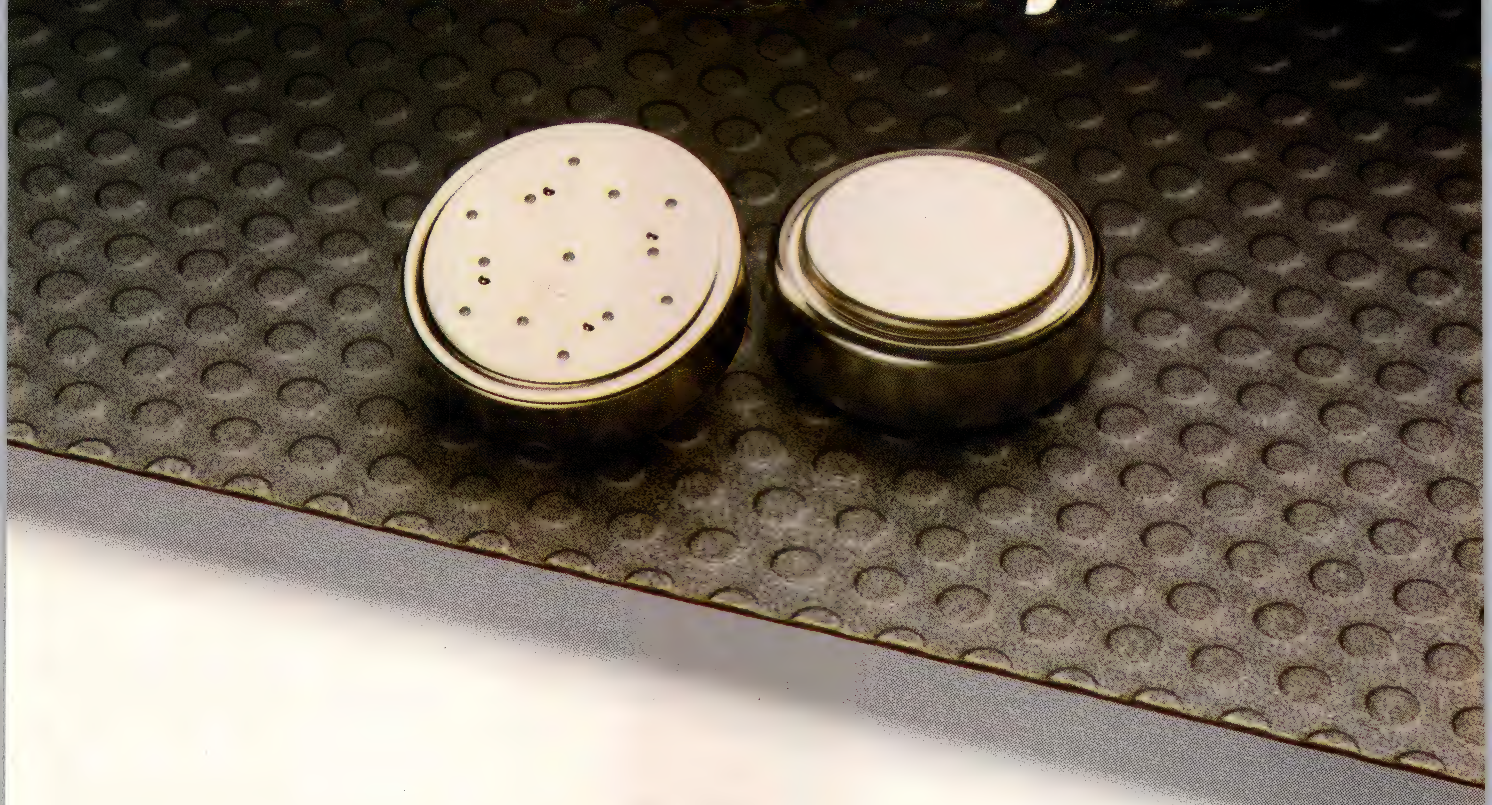
- E(E)PROM
- BIPOLAR
- PAL, FPL, PEEL
- GAL, PLD, EPLD
- 8748/8751

Testing functions

- TTL/CMOS, LOGIC IC
- MEMORY DEVICES



Presenting a battery that's not for everyone.

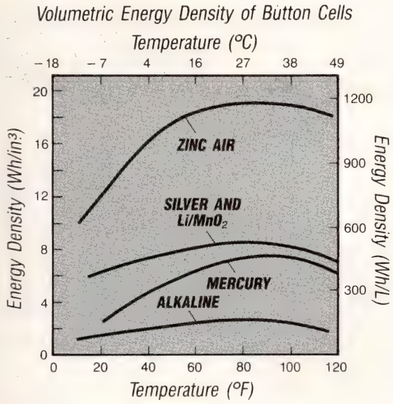


The DURACELL® Zinc Air DA1204 Cell: Only for the high energy designer.

*Our new zinc air battery isn't for everyone. But if you need a small battery with high energy, it may be for you. Since the DA1204 uses the air we breathe as the cathode, it packs more energy for its size than any battery on the market. In fact, it gives you C cell size capacity (6.6 ampere hours) in less than one-third the size.**

Sealed and waiting to be used, the DA1204 has a long shelf life — maintaining 98% of capacity after one year of storage. But because it is an air-powered battery, the DA1204 has a three month life once unsealed. It performs at a constant output voltage and is perfectly suited for medium drain, continuous-use applications with average current requirements up to 150mA. And it's available in single or multi-cell configurations.

The DURACELL Zinc Air DA1204 cell isn't for everyone, but it may be the high-energy solution you're looking for. Find out more. Call or write for complete technical information on Duracell's full line of Zinc Air batteries.



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New Products and Technology Division
OEM Sales and Marketing
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Bethel, CT 06801
Toll-free: 1-800-422-9001 ext. 425
Fax: 203-791-3273

**Batteries shown 150% of actual size.*

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CIRCLE NO. 184

mum gain error of ±3% and power dissipation of 380 mW. The DAC operates over a commercial temperature range of 0 to 70°C. In 20-pin SOIC packages or DIPs, $20.95 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (800) 548-6132. **Circle No. 430**

256k-Bit SRAM Family

- *Organized as ×1, ×4, and ×8*
- *Features numerous packaging options*

A family of 25-nsec 256k-bit static RAMs (SRAMs) is available in plastic and ceramic DIPs, and such surface-mount packages as LCCs and small-outline J leads. The family consists of the following configurations: CY7C197, 256k×1 bits; CY7C191, CY7C192, CY7C194, and CY7C196, 64k×4 bits; and CY7C198 and CY7C199, 32k×8 bits. The CY7C191 offers a transparent write for real-time data verification and independent read and write I/O pins. Similarly, the CY7C192 and CY7C197 offer independent read/write data lines. Conversely, the CY7C194/6/8/9 share read and write lines and demand time between reads and writes. CY7C191/2/8/9-25PC in plastic DIPs, $59.50; CY7C194/6/7-25PC, $45.75 (100).

Cypress Semiconductor, 3901 N First St, San Jose, CA 95134. Phone (408) 943-2600. **Circle No. 431**

Low-Power Transceiver

- *Complies with EIA interface standard*
- *Consumes <500 μA*

The LTC485 is a CMOS version of the bipolar SN75176 RS-485 transceiver. This CMOS transceiver is pin compatible with the bipolar device, yet is specified to consume 300 μA typ and 500 μA max. The low-power device can transmit data in excess of 2.5 MHz. Typical driver propagation delay is 30 nsec with 5-nsec skew. At the other end, receiver propagation delay is 100 nsec with 70-mV input hysteresis. Protection circuitry on the chip allows live insertion or removal of the device from your designs. A thermal-shutdown feature protects the circuit from short circuits. The transceiver is available in 8-pin DIPs, and an 8-pin small-outline, surface-mount version is scheduled for production. The device operates from 0 to 70°C and with a 5V±5% supply. $1.35 (100).

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (800) 637-5545; in CA, (408) 432-1900. FAX (408) 434-0507. **Circle No. 432**

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- Very easy to learn and use.
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- 48 bits wide 16K deep trace buffer.
- Complete 8051 family and 68HC11 family support.

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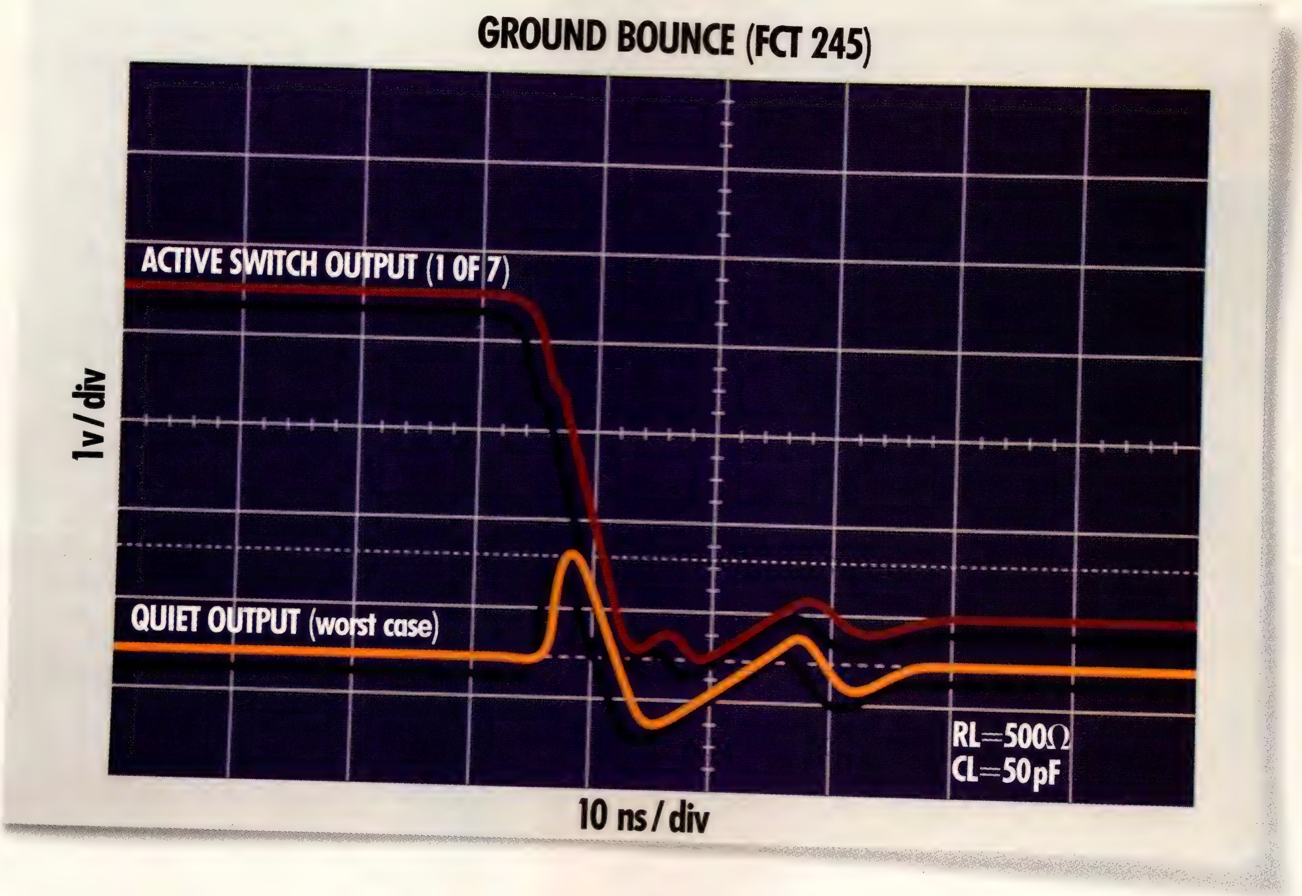
CIRCLE NO. 138

We're keeping our new FCTs quiet.

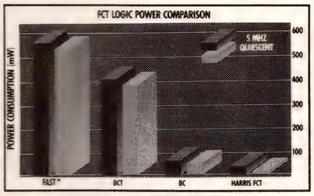


Harris' FCTs Make Less Noise.

Shhhh. Harris' new FCT logic family features low noise plus low power consumption. That's a peaceful thought when you consider that high speed in FCTs used to mean high noise and high chance of error.

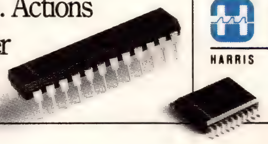
Strong, Silent Type.

By distributing NMOS pulldown technology, Harris is able to limit output voltage swing ($V = 3.7V$ @ $V_{DD} = 5.0V$), lower noise propagation, and still give you the high throughput speeds you need.



Peace Of Mind.

The low-noise, low-power, high-speed FCTs from Harris. Actions speak louder than words.



For more information and samples, call us at 1-800-4-HARRIS, ext. 1020 (in Canada, 1-800-344-2444, ext. 1020). Or call your local Harris sales office or distributor.

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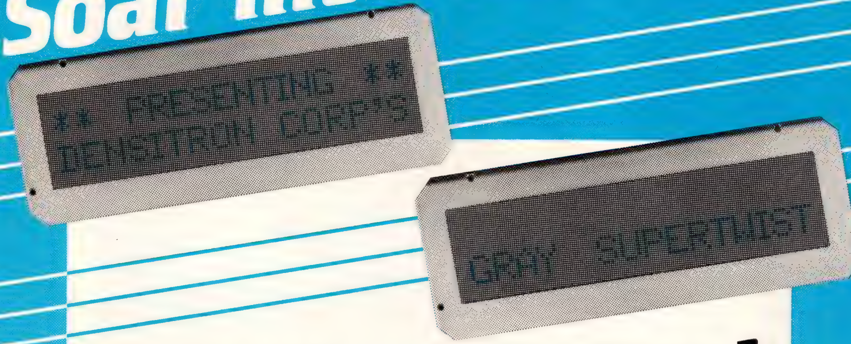
Wideband 1×1 Video Crosspoint Switch

- *Features 80-dB off-isolation*
- *Has 100-MHz frequency response*

Suitable for data acquisition as well as video applications, the GX4201 spst crosspoint switch features a frequency response of ±0.05 dB from dc to 100 MHz, an off-isolation of 80 dB at 100 MHz, and an insertion loss of 0.025 dB at 100 kHz. At 4.43 MHz, differential gain and phase are 0.01% and 0.006°, respectively. Included in the device is an open-collector "Tally" output for positive indication of switch selection. With typical input and output capacitances of 1.1 pF, an input resistance of 3 MΩ, and a high-impedance off-state, the GX4201 lets you parallel multiple inputs and outputs for large matrix configurations. In 8-pin miniDIP, $1.32; in 8-pin SOIC, $1.43 (1000).

Gennum Corp, Box 489, Stn A, Burlington, Ontario, Canada L7R-3Y3. Phone (416) 632-2996. FAX (416) 632-2055. **Circle No. 433**

Soar into the Blue



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CIRCLE NO. 151

Gate-Array Family

- *Provides as many as 85,000 usable gates*
- *Supports JTAG testability*

The five different arrays in the ICS25000 family of gate arrays offer from 55,000 to 172,000 gross gates. Pin counts for the arrays range from 196 to 352 pins, and the ICs are packaged in a variety of plastic and ceramic surface-mount and through-board packages having from 64 to 391 pins. A 2-input NAND gate with a fanout of two switches in 0.45 nsec, and output drivers can sink 16 mA with controllable slew rate. Automatic insertion of level-sensitive scan-design (LSSD) test logic, JTAG (Joint Test Action Group) adherence, and automatic test-pattern generation guarantee that fault coverage of your design is at least 99.5%. Finally, Automatic Technology Remap software performs system partitioning and allows conversion of existing products into the array family. In 68-pin plastic leaded chip package, $34.39 (5000); NRE charges, from $60,000.

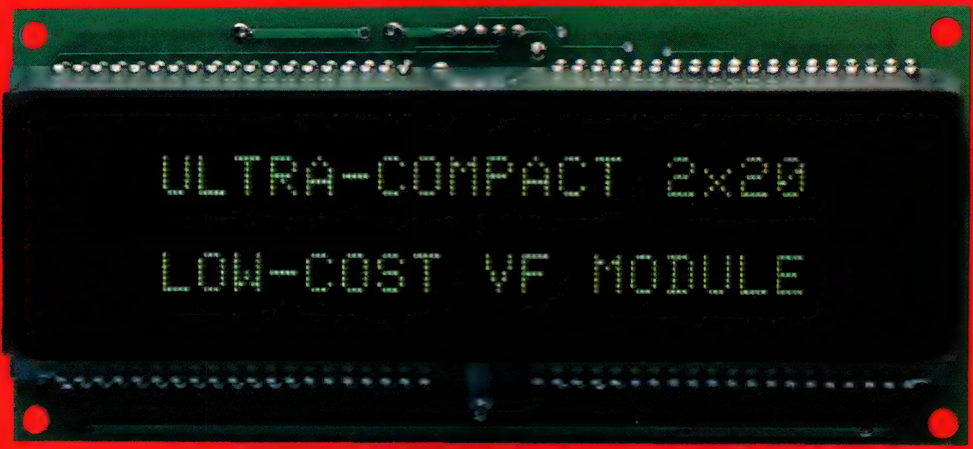
Integrated CMOS Systems Inc, 440 Oakmead Pkwy, Sunnyvale, CA 94086. Phone (408) 735-1550. **Circle No. 434**

Multiprotocol Datacomm Chip

- *Contains on-chip processor*
- *Supports 64k-bps transmit and receive data rates*

The CL-CD2400 communications controller contains four full-duplex,

THE ANSWER.



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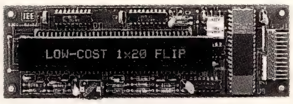

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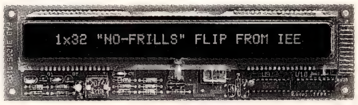

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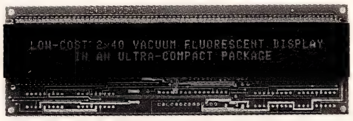
3601-87-032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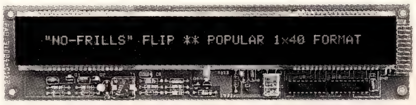

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Circle 50 for Immediate Application **Circle 51 for Reference Material**

multiprotocol channels and an 8-channel DMA controller under the control of a proprietary processor. The embedded processor minimizes the need for the host processor to control communications and reduces contention for bus time. The controller's four full-duplex channels can function independently to support different protocols. The IC also features 64k-bps transmit and receive data rates, independent bit-rate generators for transmit and receive, a double-buffered 32-bit address DMA controller for all channels, and two independent timers/channel. The chip comes in an 84-pin plastic leaded chip carrier. Sample quantities, $45; OEM qty, $40.

Cirrus Logic Inc, 1463 Centre Pointe Dr, Milpitas, CA 95035. Phone (408) 945-8300. FAX (408) 263-5682. **Circle No. 435**

IBM PC Chip

- *Supports LIM/EMS 4.0*
- *Single-chip implementation*

The HK3000 is a single-chip implementation of the peripheral logic in an 80386-based IBM PC/AT. This 386/AT chip combines the system controller, peripheral controller, and page-mode memory controller. The chip runs with the LIM/EMS 4.0 (Lotus, Intel, Microsoft/expanded memory standard), as well as shadow RAM and as many as 8M bytes of 32-bit memory. The chip runs at 25 MHz. In 208-pin plastic quad flatpack, $75 (10,000).

HK Technology Inc, 2975 Scott Blvd, Suite 203, Santa Clara, CA 95054. Phone (408) 492-1002. **Circle No. 436**

Programmable Filter Chip

- *Offers on-the-fly programming*
- *Replaces numerous discrete components*

The IMP4250 programmable filter chip operates within a range of 100 kHz to 4 MHz. The chip's 18 8-bit-wide internal registers permit 3% accuracy and give you control over the filter's characteristics as well as input and output gain. Internally, the chip serially connects four filters that you can program independently. The four can be lowpass, highpass, or phase-adjuster filters. You can also program two of the filters as elliptical or notch filters; the other two filters can be lead-lag filters. Programming is via a 3-wire serial-µP link—a read, write, and clock line. In 24-pin DIP, $18; in 28-pin plastic LCC, $18.50 (1000).

International Microelectronic Products Inc, 70 E Daggett Dr, San Jose, CA 95134. Phone (408) 432-9100. **Circle No. 437**

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- 2, 4, 6, 8 or 10 position with common bus
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- 2 SIP's require less board space than 1 DIP switch
- Compatible with pick & place equipment

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CIRCLE NO. 152

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Our reputation precedes us! From 5 subsidiaries and 35 distributors in more than 40 countries worldwide, thousands of customers purchased more in 1989 than ever before. And they were able to choose new products from an ever-expanding array of plotters, penless plotters, digitizers, recorders and supplies.

The Graphtec reputation is one of building products that work well and last a long time. We earned that reputation the hard way, by delivering over 40 years of the best innovation, support, and after-sales service in the industry.

One of the finest examples of Graphtec innovation is incorporated into our new TM1110/1210 series of thermal plotters. These plotters are unique thanks to the world's first single-substrate, large-format thermal head. The single head ensures a uniform, high-quality printout with superb 406 dpi (16 dots/mm) resolution.

Hard copies can be made on three types of media: regular, thermal transfer and clear film. Also, RS-232C and Centronics interfaces come standard, as do GP-GL and HP-GL™ command sets.

TM1110 A1-size Thermal Plotter

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*HP-GL is a trademark of the Hewlett-Packard Company.

CIRCLE NO. 148

NEW PRODUCTS

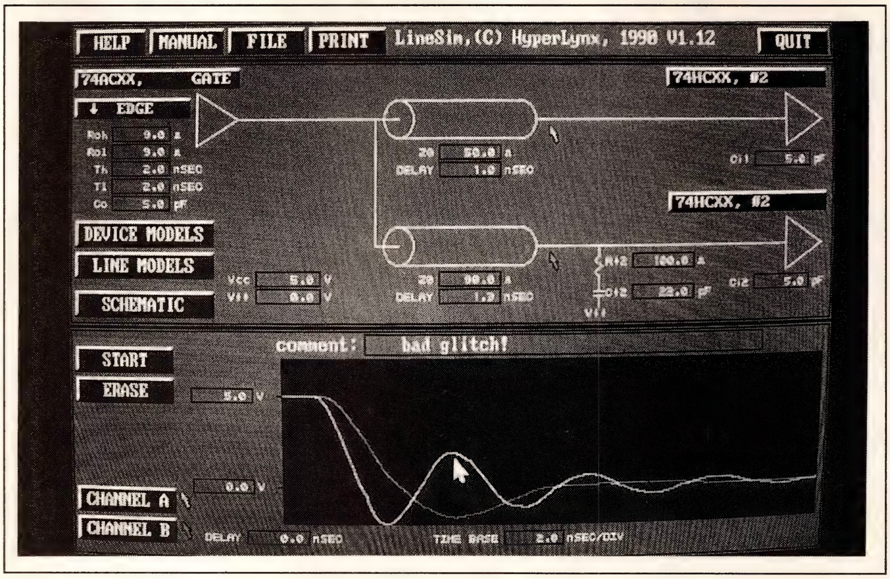
CAE & SOFTWARE DEVELOPMENT TOOLS

Printed-Circuit-Board Design Tool

- *Predicts transmission-line behavior on digital boards*
- *Helps you design critical traces before layout begins*

The LineSim circuit simulator helps you design high-speed digital boards while minimizing transmission-line effects. The program comes with a library of device models for common logic families such as 74AC, 74HC, 74F, 74AS, 74ALS, and 74LS. The models account for nonlinearities caused by dynamic driver impedance and diode clamping. The program can also model pc-board traces and calculate their transmission-line impedance from the trace dimensions and board-construction parameters, before actual layout begins. The program is window and button based; its interactive nature lets you experiment to find the proper strategies and component values for line termination. To run the program, you'll need an IBM PC/AT, PS/2, or compatible that has 640k bytes of RAM and a mouse. $595.

HyperLynx, Box 3578, Redmond, WA 98073. Phone (206) 869-2320. **Circle No. 379**



Enhanced VHDL Schematic Simulator

- *Includes EDIF translator for import of schematics*
- *Bypasses unnecessary recompilations after design changes*

VantageSpreadsheet 2.0 is a VHDL-based (VHSIC Hardware Description Language) simulation system that accepts schematics from Mentor Graphics systems or other systems via the built-in EDIF (electronic-design-interchange-format) translator and then translates them to VHDL specifications. A name-mapping facility automatically converts specific timing parameters to VHDL parameters as well as to symbol and parameter names. Other enhancements include streamlined procedures that bypass recompilation of unchanged modules after a design change; additional VHDL constructs such as "generate" and multidimensional arrays; and accelerated initialization and simulation. The software runs on Apollo and Sun workstations. $44,000/site.

Vantage Analysis Systems Inc, 42840 Christy St, Suite 201, Fremont, CA 94538. Phone (415) 659-0901. FAX (415) 659-0129.

Circle No. 380

Time-Management Software

- *Can run as a stand-alone or memory-resident program*
- *Lets you add notes to your basic things-to-do list*

To-Do List Master 2.0 is a versatile program that creates an electronic things-to-do list on your IBM PC or compatible. You can run it as a stand-alone program, which you can call from the DOS command line, or as a TSR (terminate and stay resident) program, which you can call from within any application by means of a hot key. Each item consists of a category (A to Z), a priority (1 to 9), a date and time, and a 55-character item description. If you need more space, you can add a note with as many as eight lines of text (stored in a separate file) that you can view or edit by pressing a function key. You can sort the list in various ways and create groupings by category or priority. The program takes its internal date and time from the DOS clock/calendar; if you miss an item's deadline, the entire line blinks each time you call up the program. You can delete a completed item, or you can archive it, with any associated notes, to an archive file. Both versions limit the number of entries (100 for the TSR; 300 for the nonresident), but you can create several different lists. Explicit on-screen help and instructions make the program easy to use, even if you don't read the 14-pg manual. $59.95.

Software Marketing Enterprises Inc, Box 2965, Vista, CA 92083. Phone (619) 758-2580.

Circle No. 381

Text continued on pg 279

Software-Testing Tool Set

- *Provides coverage analysis of Ada, C, Fortran, or Pascal*
- *Runs on IBM RISC System/6000 computers*

The TCAT set of test-coverage-analysis tools automates the instrumentation of programs to analyze and report test-coverage levels. The suite has six components: CapBak, which captures keystroke sequences during programmer or end-user testing of Unix or Unix-like application programs; TDGEN, a test-data generator that produces test-data files in a user-specified format; EXDiff, which compares two files and reports the differences between them; Smarts, which mechanically executes, evaluates, and reports test cases to verify the functionality of a new version with regression testing; S-TCAT, which measures the structural completeness of a test suite by reporting the percentage of function call-pairs that the test suite exercises; and TCAT-Path, which profiles the paths through a piece of software, listing all possible paths and reporting the number of paths that have been exercised. The TCAT test suite runs on IBM PS/2s and compatibles, the IBM RT PC, and RISC (reduced-instruction-set computer) System/6000 computers. $1200 to $11,500, depending on the size of the host.

Software Research Inc, 625 Third St, San Francisco, CA 94107. Phone (415) 957-1441. FAX (415) 957-0730. **Circle No. 382**

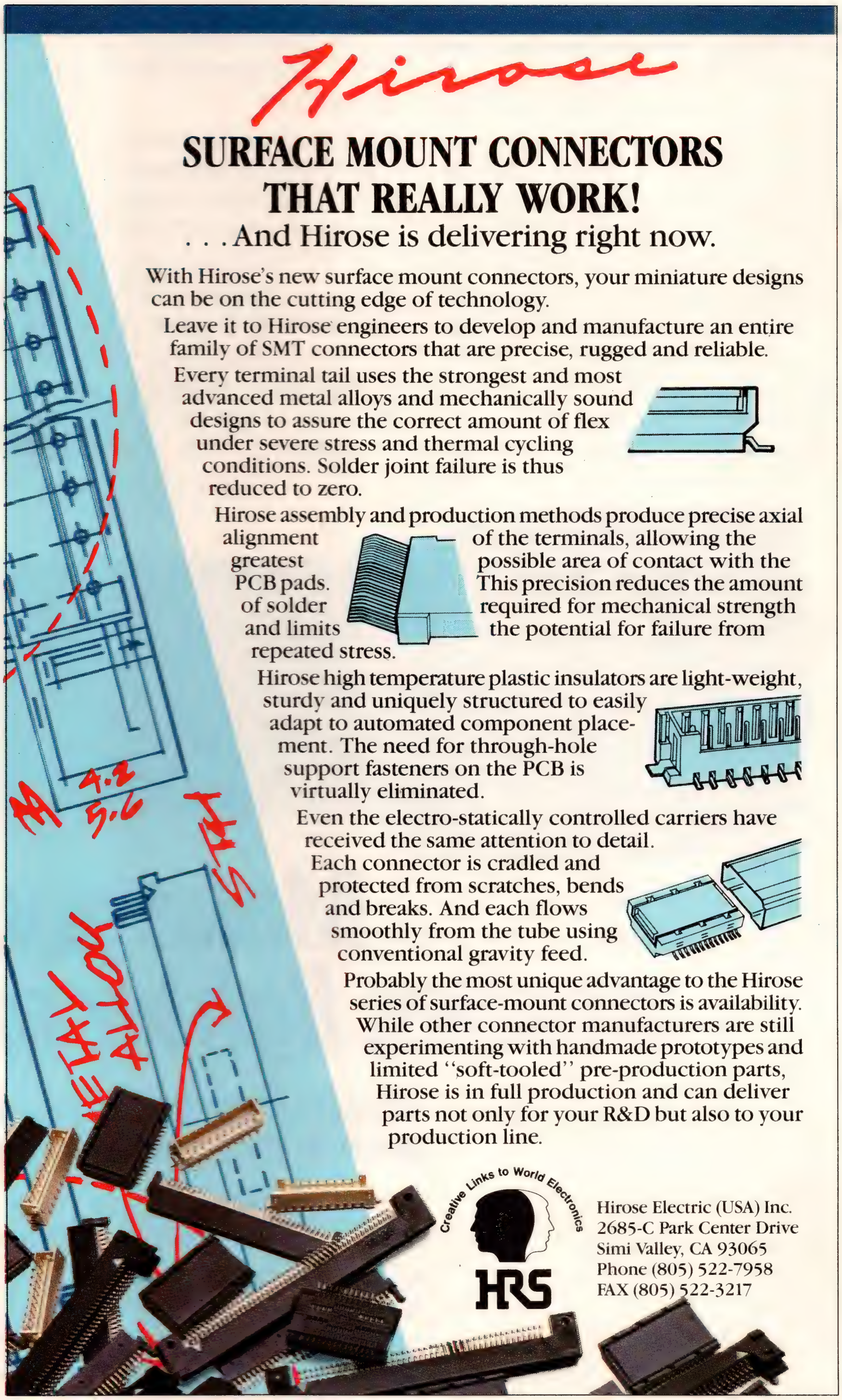
CD-ROM Data Formatter

- *Creates a CD Image file for each CD-ROM volume*
- *Converts data to High Sierra/NISO format*

The CD-Formatter conversion package runs on IBM mainframes under the MVS operating system and converts executable or data files to a CD Image file in High Sierra/NISO format. The program can create multiple image files if the data will span several CD volumes. CD-Formatter builds a directory area (similar to DOS directories and subdirectories) within the image area, which allows PC application software to access each logical file on the platter as if the file were on a hard disk. The program can output the converted data either to tape or, via a token-ring network, to magneto-optical media for mastering onto CD-ROM. $15,000.

On Line Computer Systems Inc, 20251 Century Blvd, Germantown, MD 20874. Phone (301) 428-3700. FAX (301) 428-2903.

Circle No. 383



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Every terminal tail uses the strongest and most advanced metal alloys and mechanically sound designs to assure the correct amount of flex under severe stress and thermal cycling conditions. Solder joint failure is thus reduced to zero.

Hirose assembly and production methods produce precise axial alignment of the terminals, allowing the greatest possible area of contact with the PCB pads. This precision reduces the amount of solder required for mechanical strength and limits the potential for failure from repeated stress.

Hirose high temperature plastic insulators are light-weight, sturdy and uniquely structured to easily adapt to automated component placement. The need for through-hole support fasteners on the PCB is virtually eliminated.

Even the electro-statically controlled carriers have received the same attention to detail. Each connector is cradled and protected from scratches, bends and breaks. And each flows smoothly from the tube using conventional gravity feed.

Probably the most unique advantage to the Hirose series of surface-mount connectors is availability. While other connector manufacturers are still experimenting with handmade prototypes and limited "soft-tooled" pre-production parts, Hirose is in full production and can deliver parts not only for your R&D but also to your production line.

Hirose Electric (USA) Inc.
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Phone (805) 522-7958
FAX (805) 522-3217

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CIRCLE NO. 155

Transmission-Line Analyzer

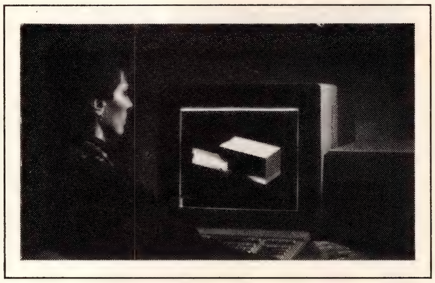
- *Can handle 10 conductors and five dielectric layers*
- *Calculates standard transmission-line parameters*

CALIF (C and L, Impedance of Fields) is an interactive, menu-driven program that runs on IBM PCs and compatibles. It uses algorithms based on Green's function to calculate the electrical properties of any single- or multiple-conductor network. The program can handle as many as 10 conductors and five dielectric layers. The conductor shapes may be rectangular, trapezoidal, circular, or polygonal, and boundary-element assignment can be either manual or automatic. The program calculates parameters such as inductance and capacitance matrices, propagation delay, impedance, crosstalk coefficients, and line resistance. The program comes with a Spice-deck generator that can generate a Spice deck for coupled transmission lines. To run the program, your PC must have a math coprocessor, IBM EGA or VGA graphics, and DOS 2.0 or later versions. $4000; optional field-plotting module, $500.

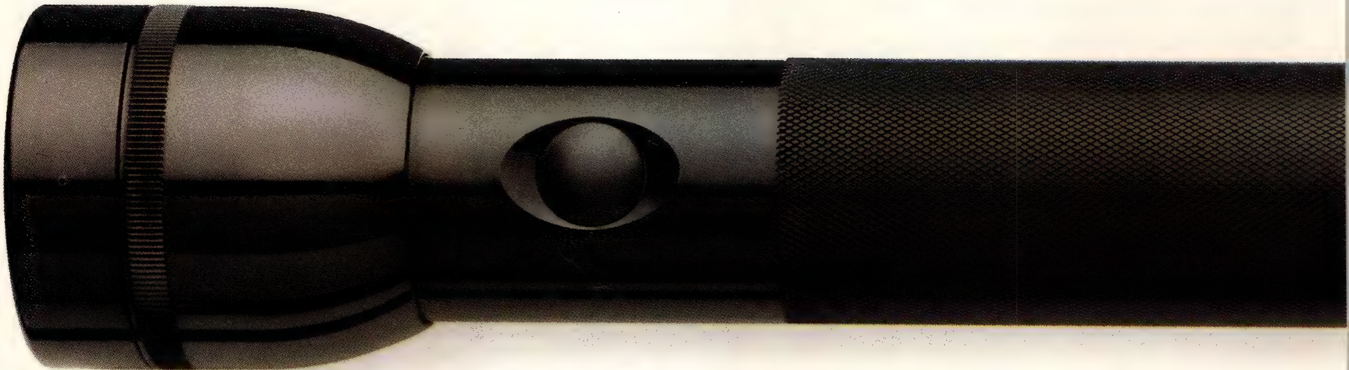
Integrity Engineering Inc, 2431 5th St, St Paul, MN 55110. Phone (612) 429-1973. **Circle No. 384**

High-Frequency Structure Simulator

- *Computes S-parameters from geometric parameters*
- *Performs electromagnetic analysis of passive RF structure*



The HP 85180A high-frequency structure simulator takes simple geometric- and material-parameter inputs relating to a passive 3-D RF or microwave structure, and automatically computes the structure's S-parameters. The simulator uses no simplifying assumptions and performs a complete electromagnetic analysis of the structure. The program calculates S-, Y-, and Z-parameters for multiport structures; places no restrictions on geometry; allows an unlimited number of dielectrics and conductors; and calculates results to user-specified accuracy. You can use the program to model transmission-line structures, discontinuities, and other circuit elements; to analyze package effects on circuit behavior; and to predict the coupling effects among high-speed digital lines. Thus, by



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relaxing tolerances that have little effect on performance, you may be able to achieve significant cost reductions. The program runs on a variety of computers, including the vendor's HP 9000 Series 300 and 800, Apollo workstations, Sun 4 computers, and SPARCstation 1. $45,000. Delivery, 12 weeks ARO.

Hewlett-Packard Co, Inquiries, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone (800) 752-0900.

Circle No. 385

Database Access Tool

- *Provides library of C routines to access Paradox*
- *Can operate in single-user or multiuser mode*

The Paradox Engine, a library of C routines, allows C programmers to build applications that access and manipulate Paradox tables in either single-user or multiuser mode. The library also provides links to the vendor's other business applications such as Quattro Pro and SideKick. $495.

Borland International, Box 660001, Scotts Valley, CA 95066. Phone (408) 439-1622.

Circle No. 386

Real-Time Kernel For i860

- *Runs on i860 RISC processor*
- *Provides standard I/O, re-entrant library, and device drivers in C*

C Executive is a real-time, multitasking ROMable kernel, which is written in C and provides all of the system services required by real-time embedded applications, including image processing. The latest version runs on Intel's i860 RISC (reduced-instruction-set computer) processor and includes standard I/O, a re-entrant C library, and a set of device drivers in C. Versions are also available for four other RISC processors and a wide variety of 8-, 16-, and 32-bit CISC (complex-instruction-set computer) processors. OEM unlimited-use fee, $25,000 for one processor type; each additional processor, $5000.

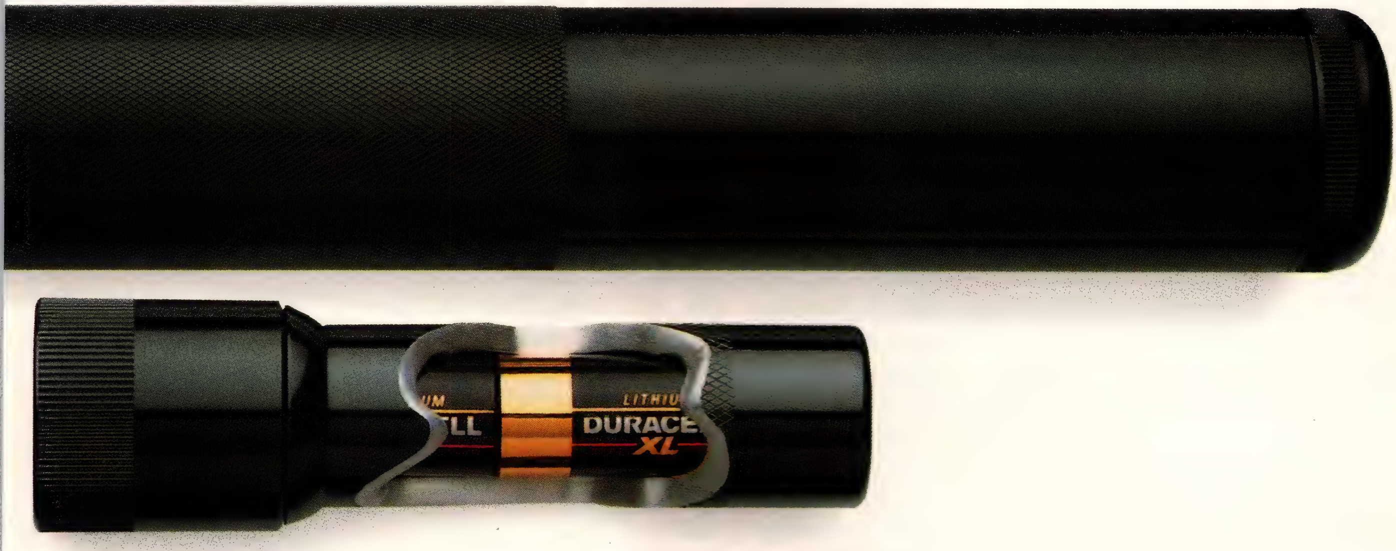
JMI Software Consultants Inc, Box 481, Spring House, PA 19477. Phone (215) 628-0846.

Circle No. 387

PLD Compiler

- *Provides on-line help for valid extensions*
- *Has a preprocessor loop index of 1024*

The CUPL 3.2 PLD compiler and simulator lets you enter designs without first specifying a device or pin number. This version supports new devices from Altera, AMD/MMI, Intel, Lattice, National Semiconductor, Signetics, Texas Instru-



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CIRCLE NO. 218

ments, and Toshiba. The program provides on-line help for all valid extensions at the end of variable names. These extensions indicate specific functions assigned to major nodes programmable within the PLD. You can now include arithmetic expressions within loops; the preprocessor loop index has a maximum value of 1024. The program can also handle PLCC (plastic-leaded-chip-carrier) versions of PLDs; the chip-diagram section of the .DOC output file shows the correct PLCC package with the signal names placed on the pins. From $1495 for the MS-DOS version.

Logical Devices Inc, 1201 NW 65th Place, Fort Lauderdale, FL 33309. Phone (305) 974-0967.

Circle No. 388

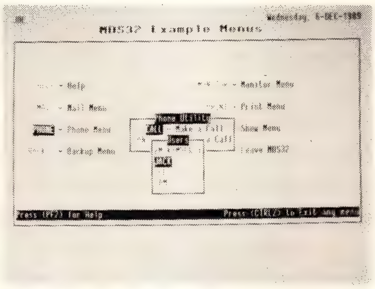
Power-Outage-Protection Software

- *Notifies network users of power outage*
- *Shuts down network when two minutes of backup power remain*

LANSoft 2.0 is a network power monitor that runs on the file server and works with the vendor's intelligent power system (IPS). Via an RS-232C link, the program continuously interrogates the IPS to check for a power outage. If a power outage occurs, the program sends a user-definable message to the file-server console for broadcast at periodic intervals to all network users. When the microprocessor in the IPS notifies LANSoft that only two minutes of backup power remain, the program shuts down the network. It notifies the IPS of shutdown completion so that the IPS can shut itself off. LANSoft works with Novell NetWare 2.1 and later versions, either as a value-added process or as a NetWare Loadable Module, and with any Proxima IPS. IPS, $649.95 (500-VA unit) to $1099.95 (1200-VA unit); LANSoft, including interface cables, $139.95.

Computer Accessories Corp, 6610 Nancy Ridge Dr, San Diego, CA 92121. Phone (619) 457-5500.

Circle No. 389



Menu-Design Tool For VAX

- *Translates C data types to VMS calling standard*
- *Uses text-based menu-definition files*

The MDS32 menu-design tool lets you design menu systems for VAX/VMS computer systems, using text-based menu-definition files. However, because the C language passes information differently from other VMS languages, C programmers have had difficulty using the tool. A new MDS32/C interface, which automatically translates C data types to the VMS calling standard observed by MDS32, allows C programmers to use the text-based menu definitions for rapid prototyping with the aid of calls to the MDS32/C interface routines. From $213 for VAXstations to $5925 for VAX 8800 series computers.

Ergodic Systems Inc, 23666-A Birtcher Rd, El Toro, CA 92630. Phone (714) 380-9719.

Circle No. 390

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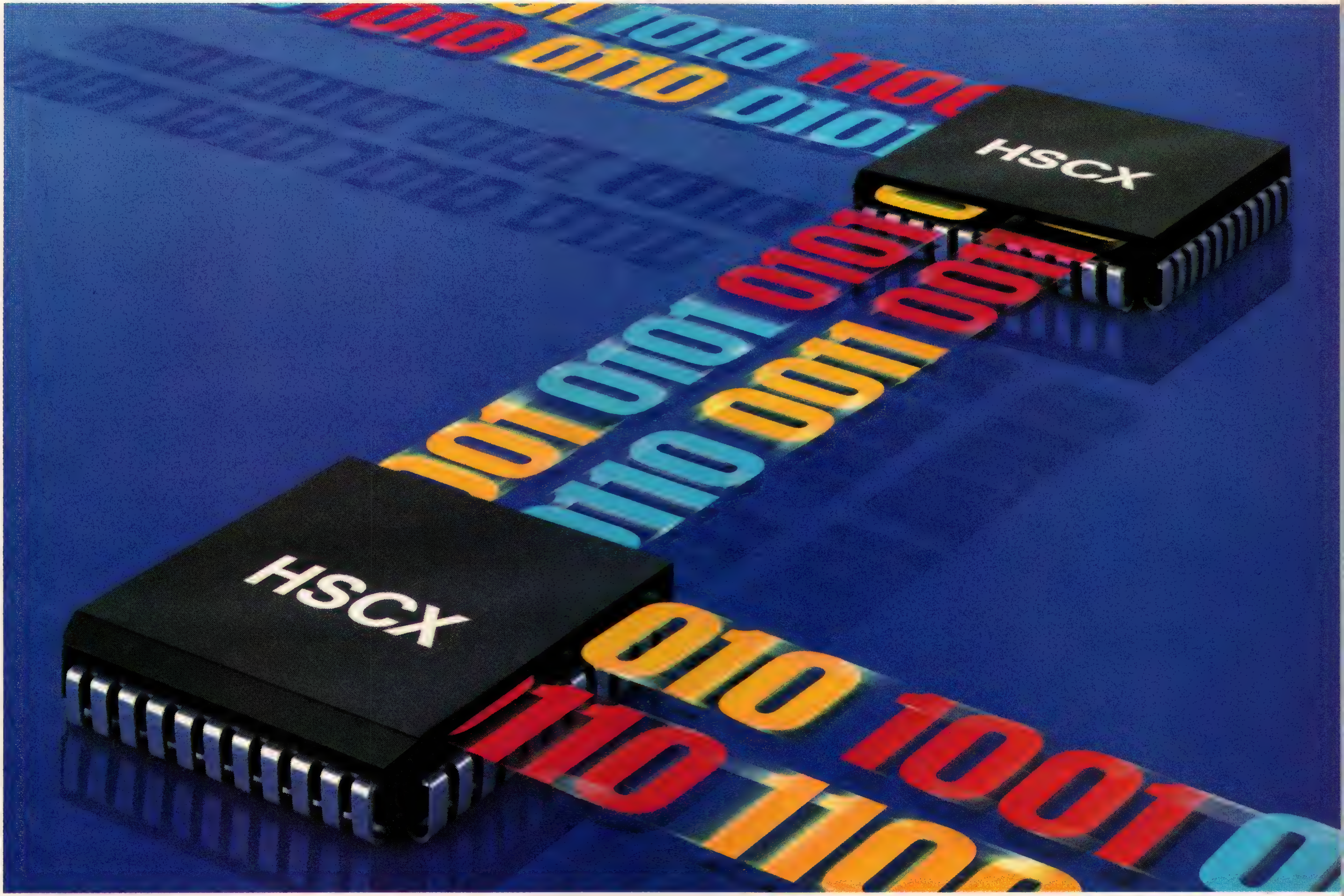
SIEMENS



High Speed Communication.

Siemens has opened a whole new line of communication which now makes it easier to successfully combine high-speed data transfer with high-level data-link control.

The Siemens High-Level Serial Communication Controller (HSCX) has all the features you need for a successful communications system. The HSCX comes with two independent bi-directional channels, and has a storage capacity of up to 17 frames in its four on-chip 64 Byte FIFOs. At a transfer speed of up to 6 Mbit/s, it supports a number of synchronous standardized protocols (HDLC, LAPB/LAPD, X.25, SDLC), and a greater number of non-proprietary protocols.

And by inverting data into programmable time slots automatically, the HSCX considerably lowers your CPU overhead, as well as reducing external glue logic.

These features provide the potential for HSCX applications in a variety of fields, such as proprietary LAN controlling networks, assembly line LANs, fast diagnostic systems, and traffic systems), as well as standardized areas such as Switching Systems and ISDN (X.25, Terminal Adaptors, and Modems).

For easy access to the wide variety and complexity of synchronous data transfer, Siemens also provides a PC-based evaluation kit.

The HSCX has already made a name for itself by providing the power needed to drive even the most complex communications systems. In fact, the biggest names in the industry already rely on the HSCX – with a great deal of success. Finally the HSCX will be sourced also by AMD. It's amazing what you can accomplish with good communication skills.

If that goes down well and you want to find out more, contact your local Siemens office or just write to:

Europe:
Siemens AG, Infoservice HL 1575,
Postfach 23 48, D-8510 Fürth

USA:
Siemens Semiconductor Group,
2191 Laurelwood Road,
Santa Clara, CA 95054
Quoting: „HSCX."

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MC&D

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CIRCLE NO. 166

VLSI Design Tool

- *Provides a structural VHDL compiler*
- *Runs on Macintosh computers*

Electric Design System is a complete, low-cost system that performs the engineering and layout tasks required in the development of digital or analog ICs. You can use it for most design technologies, including MOS and bipolar. The system includes an interactive design-rule checker, simulation interfaces, routers, a compactor, and a network-consistency checker. Additional tools include a structural VHDL (VHSIC Hardware Description Language) compiler, layout generators, and placement and routing facilities for standard cells. The program runs on Macintosh II computers under Mac-OS; your machine must have at least 5M bytes of memory (the vendor recommends 8M bytes), an 8-bit color display, and a hard-disk drive with at least 20M bytes of free storage. $4900.

Electric Editor Inc, 1440 Koll Circle, Suite 110, San Jose, CA 95112. Phone (408) 441-0710. FAX (408) 441-0814. **Circle No. 391**

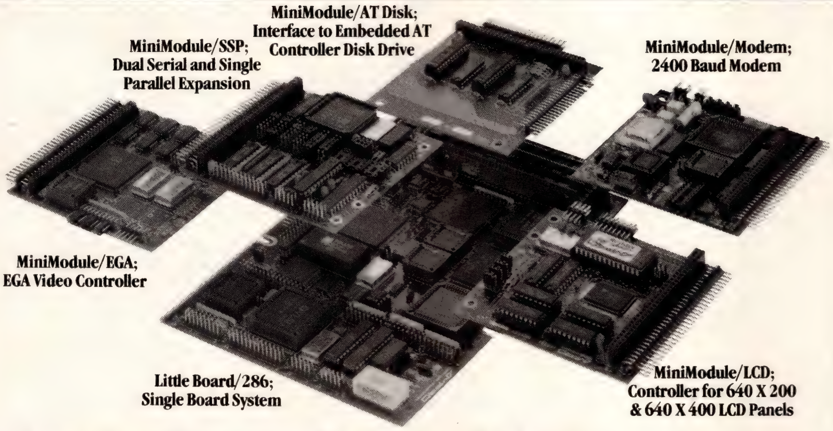
Analog And Digital CAE Tool Sets

- *Provide bundled schematic-capture and simulation tools*
- *Run on PC/ATs, PS/2s, and compatibles*

Four low-cost CAE tool sets for IBM PC/ATs, PS/2s, and compatibles include an enhanced version (CF3000) of the popular CapFast schematic-capture program, one or more simulators, and a layout package. The Digital Station consists of the CF3000 schematic-capture package and Aldec's SUSIE 4.0 digital simulator. You also get TTL, ECL, CMOS, switch, and passive functional libraries, as well as the Mobic expert model builder. The Analog Station gives you the CF3000 package with IntuSoft's IS-Spice analog simulator, the pre-Spice preprocessor, and the Probe simulation-graphing package. The Mixed CAE Station contains all of the digital and analog software listed above. Finally, the Super CAE/CAD Station adds CAD Software's PADS-PCB layout package and plotting program to the contents of the Mixed CAE/CAD package. Digital Station, $2295; Analog Station, $1995; Mixed CAE Station, $2995; Super CAE/CAD Station, $4995.

Phase Three Logic Inc, 1600 NW 167th Pl, Beaverton, OR 97006. Phone (503) 645-0313. FAX (503) 645-0207. **Circle No. 392**

Build your embedded PC or AT any way but big.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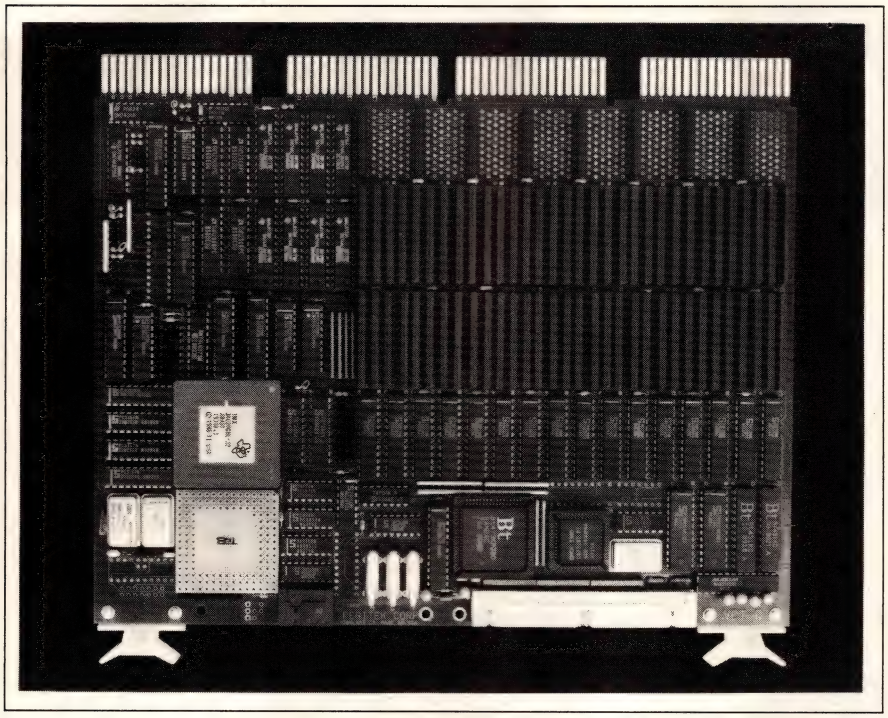
CIRCLE NO. 131



Color Graphics-Controller Board

- *Provides 1024 × 1024 × 24-bit resolution*
- *Uses a TMS-34020 graphics-system processor chip*

The VCT-Q is a 24-bit color graphics-controller board for the Q Bus in DEC computers. It displays graphics with 1024 × 1024 × 24-bit resolution. The controller also can perform 1024 × 1024 × 4-bit graphics overlays. You can optionally expand the board's display memory to 2048 × 1024 addressable pixels. The board uses a TI TMS-34020 graphics-system controller IC for pattern-fill functions. A Brooktree BT473 color-map controller IC provides 16.7 million colors. Other features include four RS-232C ports,

Text continued on pg 289

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Communications Automation & Control

CIRCLE NO. 153

a SCSI port, a 1-to-16 horizontal zoom, and a 2-to-16 vertical zoom. The board also has a socket for an optional TMS-34082 floating-point unit. You can program the board for interlaced or noninterlaced operation. $8200. Delivery, 60 days ARO.

Peritek Corp, 5550 Redwood Rd, Oakland, CA 94619. Phone (415) 531-6500. FAX (415) 530-8563.
Circle No. 408

Ultrasonic Tape Measures

- *Have 0.007-in. resolution in the range of 0.5 to 60 ft*
- *Remote units communicate with host located 100 ft away*

The RMU-200 and the RMU-2000 ultrasonic tape measures contain two Polaroid transducers and communicate with a host located as far as 100 ft away. The remote standalone units transmit data in ASCII format over an RS-232C or RS-422 link at 9600 baud. The devices have a distance range of 0.5 to 60 ft with 0.007-in. resolution. Other features include ±1% accuracy, a 12° beam width, a temperature range of 0 to 70°C, and a noncondensing relative humidity of 5 to 95%. The units measure 3×4×5 in. and operate from a wall-mount power supply. Both units report data continuously to the computer. However, the RMU-2000 can also transmit data under program control. From $545.

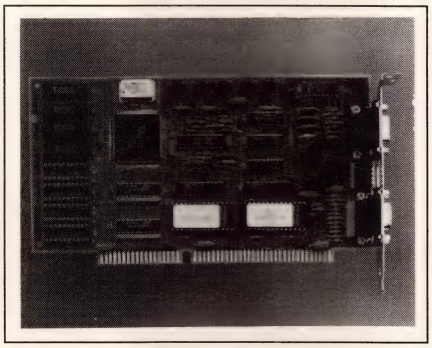
Contaq Technologies Corp, 15 Main St, Bristol, VT 05443. Phone (802) 453-3332. FAX (802) 453-4250.
Circle No. 409

VMEbus-To-Mainframe Interface

- *Emulates IBM's 3422 magnetic tape and 3274-1A control unit*
- *Transfers data to an IBM channel at 2M, 3M, or 4.5M bytes/sec*

The ChannelAxcess 9400 VMEbus board interfaces a VME system to an IBM mainframe channel. The board emulates IBM 3422 magnetic tape and a 3274-1A control unit. It uses a 68020 CPU to transfer data to an IBM mainframe channel at 2M, 3M, or 4.5M bytes. The board has four channel connector blocks and connectors for a remote on-line switch. The connector-block circuitry lets you remove the unit from the chassis without disconnecting the external bus. $7500.

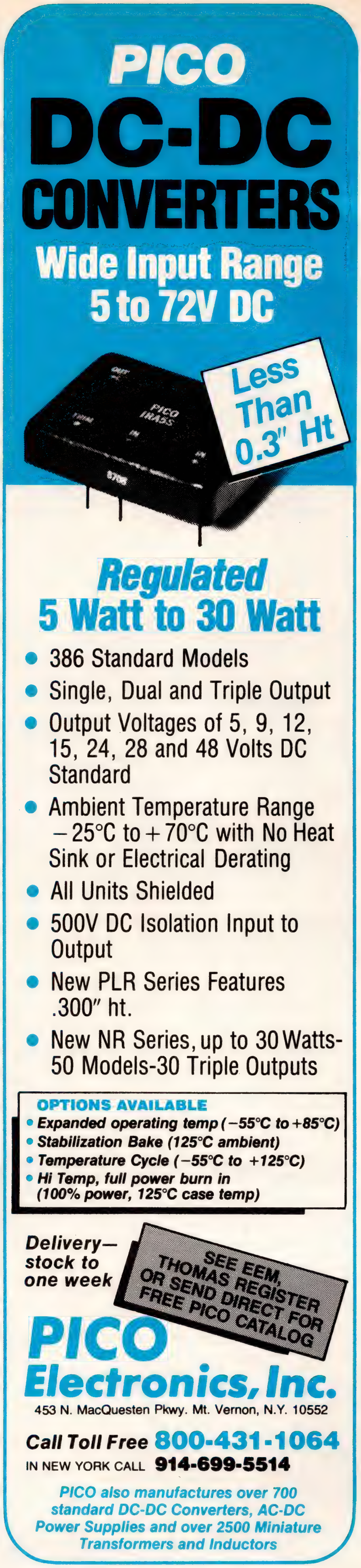
KMW Systems Corp, 6034 W Courtyard Dr, Austin, TX 78730. Phone (512) 338-3000. FAX (512) 338-3199. **Circle No. 410**



IBM VGA Board

- *Designed for the 16-bit ISA bus in an industrial computer*
- *Uses Tseng Lab's ET4000 VGA controller IC*

The V^{2}GA is a super VGA board for use in the company's industrial computers. The 16-bit board uses industrial-quality components and has separate power and ground planes to minimize RFI. Using



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CIRCLE NO. 169

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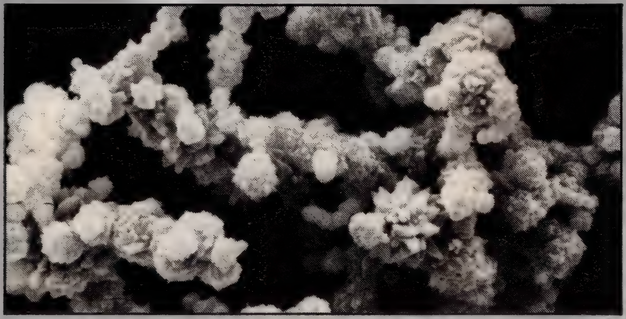
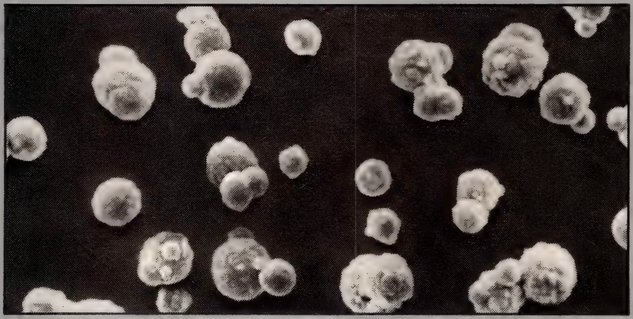
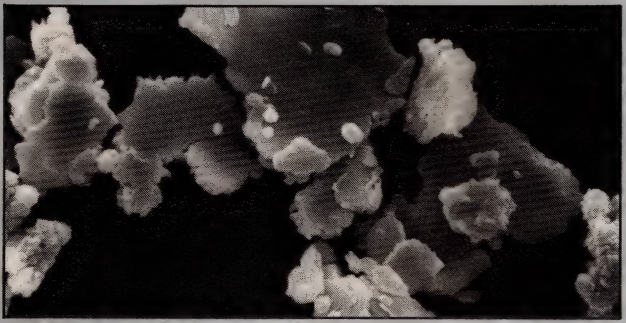


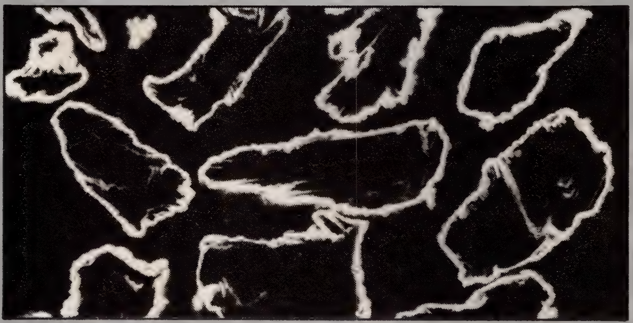
Inco Type T 287 Filamentary Powder, particle size (FSSS) 2.6-3.3 microns, apparent density 0.75-0.95 g/cc, relative surface resistivity 0.30 ohms per square (□).



Novamet Silver Coated Nickel Spheres, 15% Ag, 2.5 g/cc apparent density, particle size 10 microns, screen mesh 99%-250, surface resistivity 0.03 Ω/□.



Novamet HCA-1 Flake, screen mesh 98% minus 400, apparent density 0.90 g/cc, thickness 1.0-1.1 microns, surface resistivity 0.25 Ω/□.



Novamet Nickel Coated Graphite, 60% fully encapsulated Ni, apparent density 1.6 g/cc, particle size (FSSS) 100 microns, screen mesh 63% −150/+250, surface resistivity 0.3 Ω/□.

Inco Specialty Powder Products now has a wide range of nickel and coated powders with exceptional conductive and magnetic properties. These properties make them ideal for a spectrum of electronic applications such as conducting film technology, coatings, adhesives, gaskets and EMI shielding.

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The development of computer processed control coupled with the continuous powder production improvements enables us to meet your most stringent powder specifications for electronic applications.

In addition to the products pictured above, INCO SPP has available the following high performance powder products. Novamet Conductive Nickel Spheres, particle size (FSSS) 8-9 microns, apparent density 3.2-3.5 g/cc, surface resistivity 1.0 ohms per square. Novamet 525 Conductive Nickel Pigment, screen mesh 100% minus 400, particle size 3.2 microns, 0.65 BET surface area m^2/g, surface resistivity 0.35 ohms per square. Silver Coated Nickel Flake, 15% Ag, 2.6 g/cc apparent density, particle size (FSSS) 15 microns, screen mesh 99% minus 200, surface resistivity 0.04 ohms per square.

Magnetic ferrites and surge arrestor applications also use our specialized range of nickel oxides. High Purity Black Nickel Oxide, 77.2% Ni, BET 75 (m^2/g) particle size (FSSS) 5.2 microns, minus 325 mesh 99% plus. Green Nickel Oxide, 78.5% Ni, BET 3 (m^2/g) particle size 1.6 microns, −325 mesh 100%.

Inco Specialty Powder Products is your unique source for custom fitting high performance powders into electronic applications. Our customer focused, worldwide marketing service group is ready to help you with your current and future needs.

For more information write INCO Specialty Powder Products, Dept. 1-90, Park 80 West-Plaza Two, Saddle Brook, NJ 07662

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1-3 Grosvenor Place, London SW1X7EA England
15/Fl Wilson House, 19-27 Wyndham Street Central, Hong Kong

Tseng Lab's ET4000 VGA controller IC, the board provides a resolution of 1024×768 pixels on noninterlaced monitors. It displays 256 colors from a palette of 256,000 colors. You can opt for as much as 1M byte of video RAM. Extended graphics modes provide 640×480-, 800×600-, and 1024×768-pixel resolutions with multifrequency analog monitors. Extended text modes provide 132×25, 132×28, 132×44, 100×40, and 80×60 column×line resolutions. The board has both analog and graphics outputs. Software drivers, included with the board, run extended text modes in Word Perfect applications. $450 for a board with 512k bytes of RAM.

Texas Microsystems, 10618 Rockley Rd, Houston, TX 77099. Phone (800) 627-8700. FAX (713) 933-1029. **Circle No. 411**

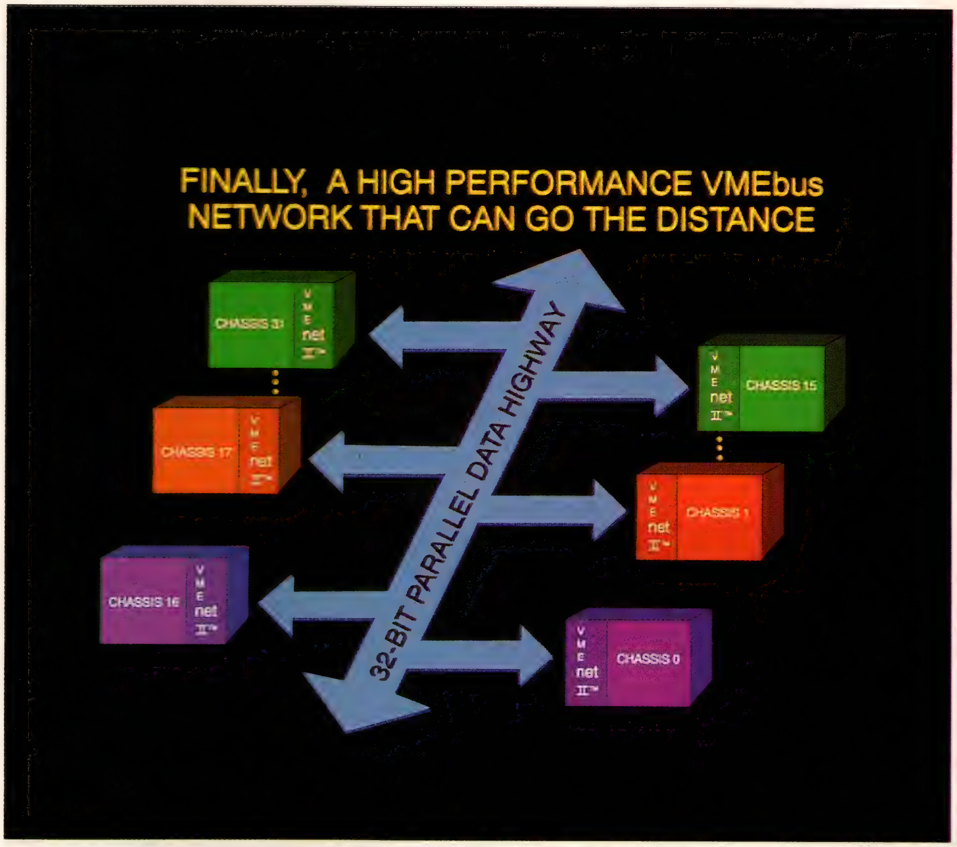
Ethernet Bridge

- *Filters more than 23,000 packets/sec*
- *Communicates at the MAC layer of the ISO network model*

The NB2010 Ethernet bridge filters more than 23,000 packets/sec and forwards more than 14,000 packets/sec. The bridge communicates at the Media Access Control (MAC) level of the ISO network model, which allows mixed protocols to operate over the network. The bridge handles TCP/IP (transmission control protocol/internet protocol) and DECnet communications, among others. It performs multicast-address filtering to reduce the number of broadcast messages sent to other networks. The bridge also has source-address filtering, which prohibits certain networks on the node from transmitting to the rest of the network. Protocol-type filtering restricts chosen protocols from transmission over designated network segments. A built-in self-learning algorithm informs the bridges which devices are on the network. The company's Network Bridge Management System provides network management. $4995.

TRW Information Networks Div, 23800 Hawthorne Blvd, Torrance, CA 90505. Phone (213) 373-9161. FAX (213) 375-5805.

Circle No. 412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CIRCLE NO. 157

High-Performance Interface Switch

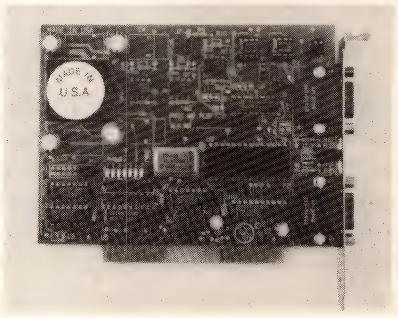
- *Has eight input and output ports operating at 800M bps each*
- *Has no data buffers or protocol converters*

The P8 HPPI is a high-performance interface switch. ANSI Working Group X3T9.3 is currently making HPPI (high-performance parallel interface) a standard. An HPPI connection consists of a simplex path that has unidirectional data flow with control signals in both directions. The P8 HPPI switch has eight input and output simplex ports operating at 800M bps each. The eight simultaneous simplex connections permit aggregate data to flow through the switch at 6.4G bps. A network built with one or more switches preserves the HPPI protocol throughout the network. The switch has no data buffers or protocol converters, so the data latency is less than 200 nsec. The switch resides in a 16-card chassis where one card contains a pair of input and output ports. A built-in self-test board occupies another slot in the chassis. $56,000.

Network Systems Corp, 7600 Boone Ave N, Minneapolis, MN 55428. Phone (612) 424-4888. FAX (612) 424-2853. **Circle No. 413**

Opto-Isolated Serial Card

- *Has an RS-422 and an RS-485 port*
- *Transfers data as fast as 288,000 bps*



The PLCP0050 opto-isolated serial card for the ISA bus contains an RS-422 and an RS-485 port and can communicate at a distance of 4000 ft. The card's serial controller, an enhanced 8250A UART, contains independent 4-byte-long Tx and Rx FIFO buffers, two 16-bit timer/counters, and 35 addressable registers for controlling I/O characters and error checking. The board can transfer data as fast as 288,000 bps. You can place its base address on any 8-byte boundary in the IBM I/O space below 1024. For a base address of 1016 or 760, the card operates as a COM1 or COM2 card, respectively. You can set the hardware interrupt level at IRQ 2 through IRQ 7. A wait-state generator can generate from zero to three wait states, and the board can generate and respond to microLAN protocols. $220.

Control and Data Technologies, 327 S Walnut St, Beaver, PA 15009. Phone (412) 775-3456.
Circle No. 414

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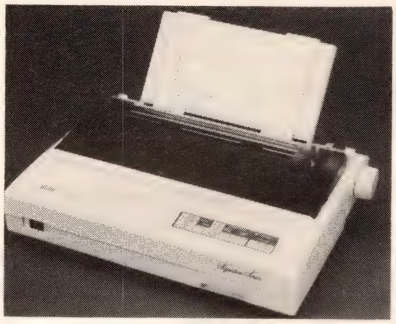
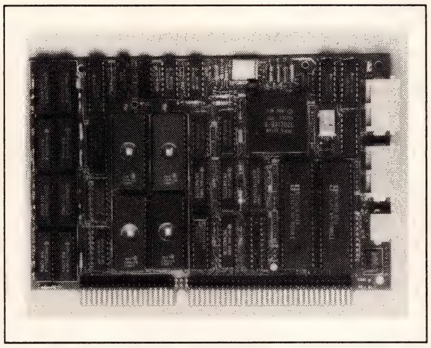


24-Wire Dot-Matrix Printer

- *Prints at 180 cps in draft and 60 cps in letter-quality mode*
- *Has a parallel interface and emulates Epson's LQ-850 printer*

The NX-2410 Multi-Font is a 24-wire dot-matrix printer. It prints at 180 cps in draft-elite mode and 60 cps in letter-quality mode. In graphics applications, the printer can provide 360×360-dpi resolution. It can print its four resident fonts, Courier, Prestige, Orator, and Script, in pica, elite, condensed pica, condensed elite, and proportional sizes. You can opt for Letter Gothic, Blippo, and OCR B fonts on font cards. You can also store downloaded fonts on an optional 32k-byte RAM card. The printer's paper-handling features include paper parking, automatic paper handling, an adjustable push-tractor feed, and a forward and reverse microfeed. An optional automatic 50-sheet feeder is also available. The printer has a parallel interface and emulates an Epson LQ-850 and an IBM Proprinter X24 printer. A 7k-byte data buffer expands to 39k bytes with the 32k-byte RAM card. $499.

Star Micronics Inc, 200 Park Ave, Suite 3510, New York, NY 10166. Phone (212) 986-6770. TWX (710) 581-4082. **Circle No. 415**



CPU Card

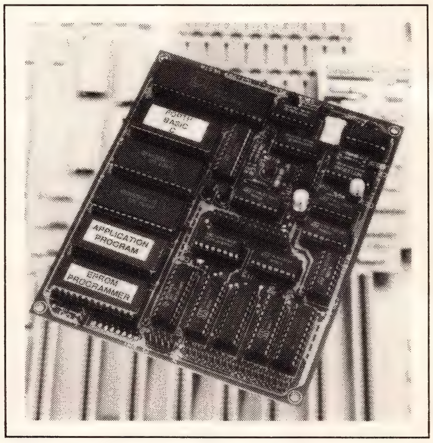
- *Runs MS-DOS from EPROM for diskless operation*
- *Has an NEC V-50 μP and as much as 1M byte of RAM*

The KS-5 CPU card for the ISA bus has either an 8-, 10-, or 12.5-MHz NEC V-50 μP and either 512k or 1M byte of dynamic RAM. The board contains four 28-pin sockets, which you can populate with as much as 256k bytes of EPROM. You can store MS-DOS 3.3 in 83k bytes of the EPROM space, which leaves 173k bytes free for running diskless applications. A standard card consumes 400 mA, and an all-CMOS version consumes 200 mA. The 4.5×6.9-in. card has as many as five RS-232C ports and a 98-pin I/O expansion connector with the same pinouts of the ISA bus. Optional piggyback cards, which attach to the expansion connector, have printer, SCSI, floppy-disk-drive, and keyboard ports. $299.

Kila Systems, 655 Hawthorne Ave, Boulder, CO 80304. Phone (303) 444-7737. FAX (303) 786-9983. **Circle No. 416**

Single-Board Computer

- *Contains an 8088 μP and 8-channel A/D converter*
- *Includes Basic, C, or Forth languages in ROM*



The SBC88A single-board computer has an 8088 CPU and measures 5½×4½ in. It contains either Basic, C, or Forth languages in ROM and an EPROM programmer for storing an application program downloaded from a host computer. A PC host downloads source code to the board via an RS-232C link. The Forth and Basic languages have built-in debugging features. The C language comes with a host-resident debugger that controls execution and views data during program execution. In addition, the

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board contains an 8-channel 8-bit A/D converter (10-bit optional), 23 digital I/O lines, and a time-of-day clock. Basic version, $99.

Vesta Technology Inc, 7100 W 44th Ave, Suite 101, Wheatridge, CO 80033. Phone (303) 422-8088. FAX (303) 422-9800.

Circle No. 417

Color Printer

- *Employs dry-silver media for printing A-size sheets*
- *Produces 300-dpi prints with as many as 32,768 colors*

The Colorado is a color printer for 3M Corp's dry-silver color paper and transparencies. It produces both continuous-tone color and gray-scale images in page-print and strip-chart formats. The desktop unit produces continuous strip records for $1.12/ft and 6×8-in. color prints for $0.75. The printer produces images with 300-dpi resolution and 32,768 colors. It can produce A-size color prints in 30 sec and each successive print in 15 sec. The printer employs a CRT with red, green, and blue phosphors to expose a silver-halide-coated paper. The paper is driven past the CRT and then thermally developed. The thermal processor develops the paper at 270 to 280°C before generating a hard copy. An electrical adjustment to the CRT calibrates the process to ensure consistent color images. $10,500. The printer will be available in July.

Honeywell TID Inquiry Services, 5105 E 41st Ave, Denver, CO 80216. Phone (303) 773-4581.

Circle No. 418

VMEbus Single-Board Computers

- *Have a 25- or 33-MHz 68040 CPU*
- *Use the FGA-002 ASIC for message broadcasting*

The CPU-40 and CPU-41 are single-board computers for the VMEbus. The boards have either a 25- or 33-MHz 68040 CPU, which couples to the company's FGA-002 ASIC for message broadcasting and mailbox interrupt handling. The CPU-40 has as much as 16M bytes of dynamic RAM, and the CPU-41 contains as much as 4M bytes of static RAM (SRAM). Other features include two dual-universal serial communications controllers, a battery-backed 32k-byte SRAM and real-time clock, two parallel interface/timers, a 4-level arbiter, a 32-bit DMA controller, and two 32-pin EPROM sockets. The boards use the company's local expansion interface for adding optional daughter modules, called Eagle modules, without occupying extra backplane slots. In addition, the boards in-

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clude VMEPROM, which is a real-time kernel and monitor. $4000 to $10,000, depending on options.

Force Computers Inc, 3165 Winchester Blvd, Campbell, CA 95008. Phone (408) 370-6300. FAX (408) 374-1146. **Circle No. 419**

Force Computers GmbH, Prof-Messerschmitt-Strasse, D-8014 Neubiberg, Munich, West Germany. Phone (089) 608140. FAX (089) 6097793. **Circle No. 420**

ArcNet Board

- *Operates four subnetworks for EISA bus*
- *Provides 2.5M-bps data rates for each LAN*

The ArcNet-EISA3200 is a 32-bit ArcNet plug-in board for the EISA bus. The board occupies one expansion slot in a file server that controls multiple subnetworks of an ArcNet LAN. It provides 2.5M-bps transfer rates for each of the four subnetworks, resulting in an aggregate transfer rate of 10M bps. The subnetworks can be configured as a bus or star topology and can operate simultaneously using parallel processing. Operating as a bus master, the board can transfer data to the host memory using burst mode at 33M bytes/sec. An onboard processor relieves the host of the communications tasks. Coax or twisted-pair version, $995.

Standard Microsystems Corp, Systems Products Div, 35 Marcus Blvd, Hauppauge, NY 11788. Phone (800) 762-4968; in NY, (516) 273-3100. **Circle No. 421**

Bar-Code Reader

- *Uses the PC's μP as a decoder*
- *Consists of plug-in card, steel wand, and disk software*

The FlexScan bar-code reader works with ISA bus computers. Unlike most readers that use a separate microcontroller for decoding the bar code, the reader uses the PC's μP. It consists of a plug-in card, a stainless-steel wand, and disk-resident software. The device provides software drivers for the following bar codes: Code 39, Code 128, Interleaved 2 of 5, and Codabar. It also operates with standard bar code options such as full ASCII Code 39 or UPC addendums. You can program the unit to add a carriage return, beep, or to flash the video screen to indicate a good read. Also included is a program called ScanRite, which explains the best way to scan bar codes and lets the user observe the velocity of the wand during training. $295.

Adaptive Technologies, 810-208 Los Vallecitos, San Marcos, CA 92069. Phone (619) 744-8087. FAX (619) 744-9256. **Circle No. 422**

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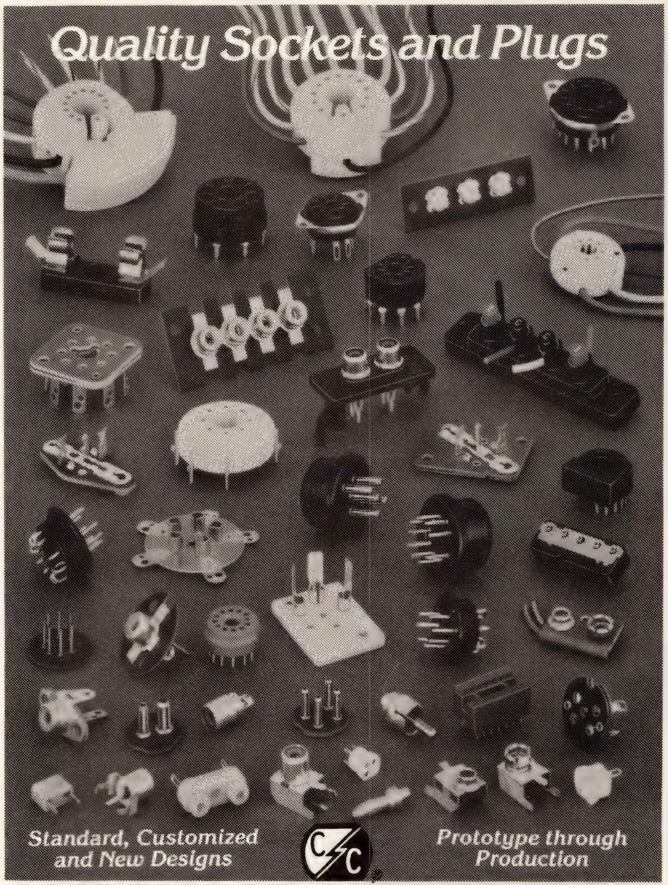

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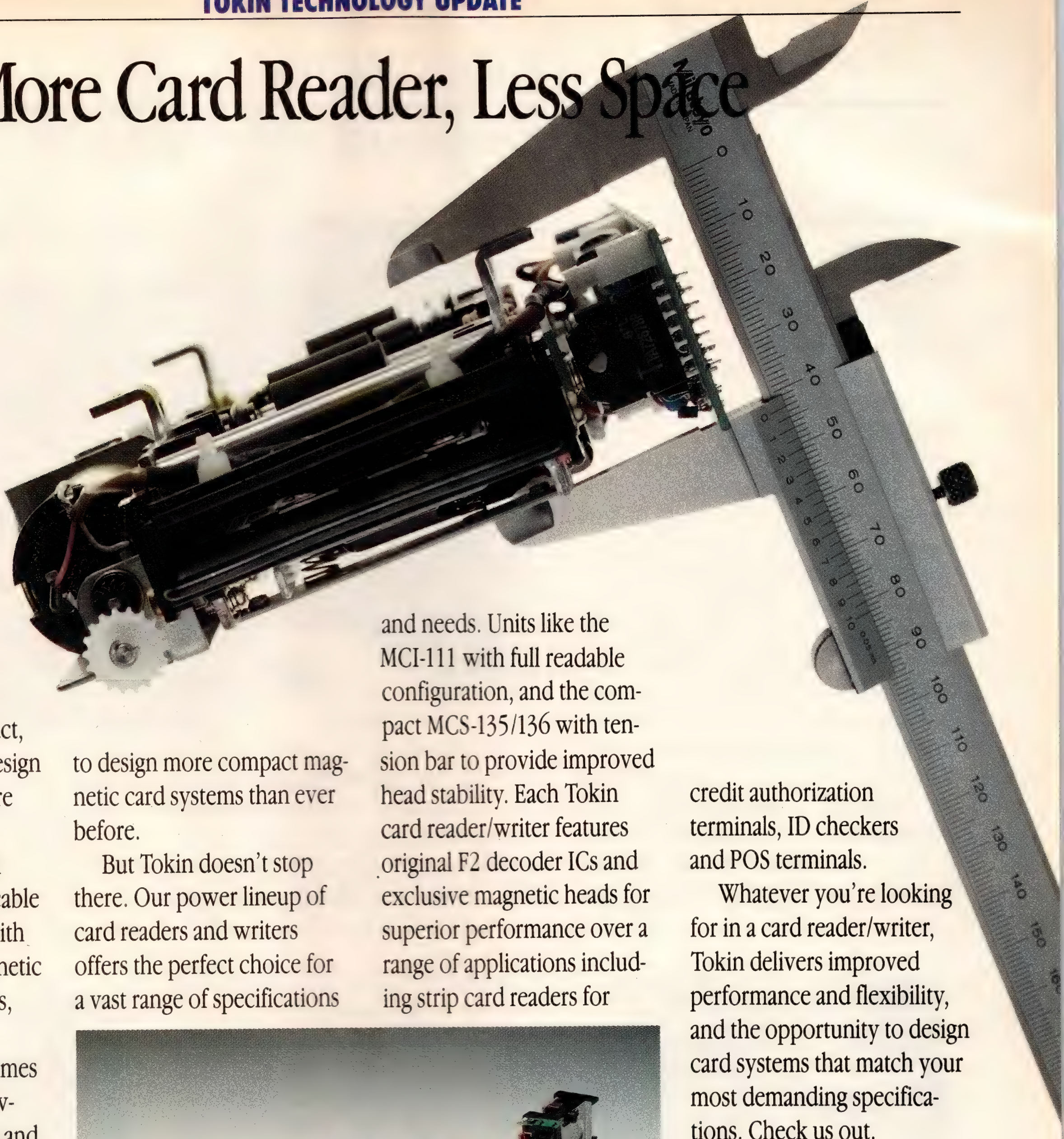


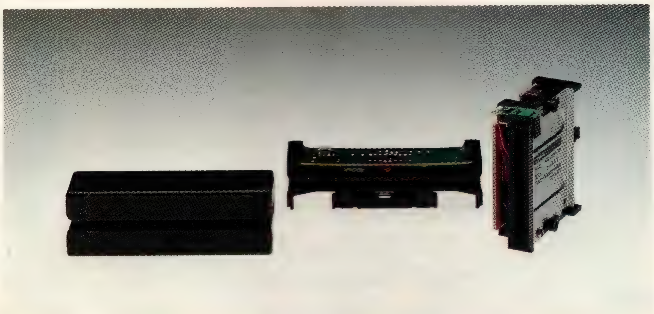
It's here. The designer's dream: A motorized card reader so small, so compact, so lightweight, you can design it into any system you dare imagine.

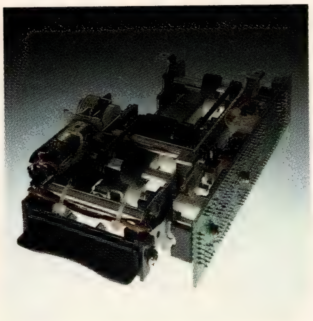
Tokin's new MCA-1601 boasts the kind of impeccable design that only Tokin, with a full half-century of magnetic engineering achievements, can produce.

The MCA-1601 overcomes card readers' biggest drawback—size. Slim (46mm) and lightweight (700g), it gives you the power and flexibility to design more compact magnetic card systems than ever before.

But Tokin doesn't stop there. Our power lineup of card readers and writers offers the perfect choice for a vast range of specifications and needs. Units like the MCI-111 with full readable configuration, and the compact MCS-135/136 with tension bar to provide improved head stability. Each Tokin card reader/writer features original F2 decoder ICs and exclusive magnetic heads for superior performance over a range of applications including strip card readers for credit authorization terminals, ID checkers and POS terminals.

Whatever you're looking for in a card reader/writer, Tokin delivers improved performance and flexibility, and the opportunity to design card systems that match your most demanding specifications. Check us out.





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Manual magnetic card reader/writer unit

Model	Card standard	Features	Dimensions (mm)
MCS-135	ISO 3554 Track 1 and 2	One way, double track: simultaneous reading	100×32×32.5 (with cover)
MCS-136	ISO 3554 Track 2 and 3	One way, double track: simultaneous reading	
MCI-111	ISO 3554 Track 2	Magnetic card insertion system	67×65×24

Motorized magnetic card reader/writer unit

Model	Card standard	Features	Dimensions D×W×H (mm)
MCA-1601	Accepts all standards	Extremely thin and half the volume*	183×139×45.4

*Compared with conventional Tokin models.

TOKIN

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Hazama Bldg., 5-8, Kita-Aoyama 2-chome, Minato-ku, Tokyo 107, Japan
Phone: 03-402-6166 Fax: 03-497-9756 Telex: 02422695 TOKIN J

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Chicago Branch
9935 Capitol Drive, Wheeling, Illinois 60090, U.S.A.
Phone: 708-215-8802 Fax: 708-215-8804

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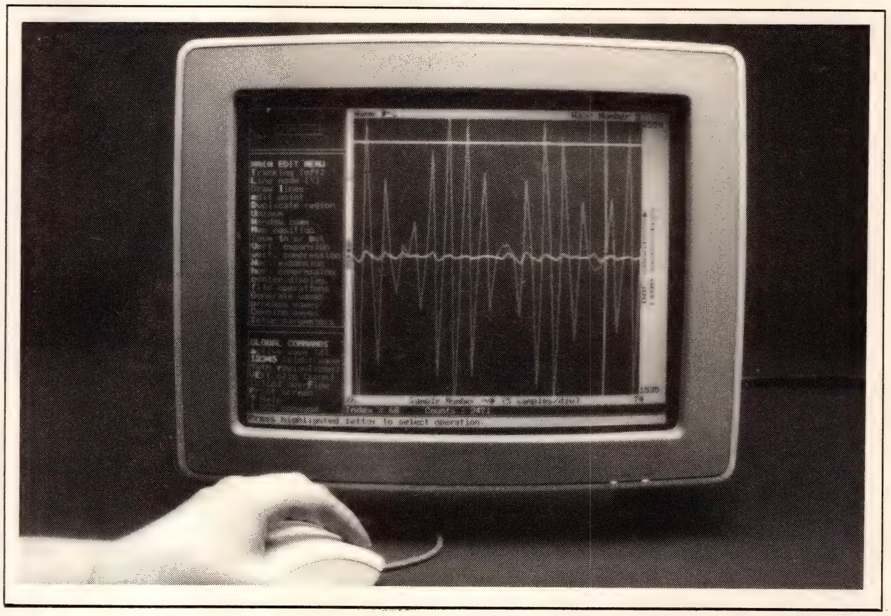
CIRCLE NO. 158

Waveform-Generation Software

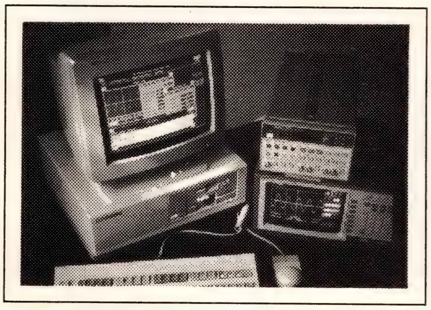
- *Files compatible with many waveform generators*
- *Runs on most mouse-equipped IBM PC-compatible computers*

R4 software lets you create and edit arbitrary waveforms that generators made by the vendor and others will then reproduce. The menu-driven package works on IBM PC-compatible computers equipped with a Microsoft or Mouse Systems serial mouse and a display that conforms to the Hercules or IBM EGA standards. Using the mouse, you can sketch waveforms freehand. You can also define them dot by dot or by editing signals previously acquired via an ADC. The software can handle five 32,000-point waveforms and can add, subtract, multiply, divide, smooth, and convolve them. A zoom function lets you observe and modify waveform details. The waveform library includes sine, square, triangle, exponential, Gaussian, and sin(x)/x functions. $995; when purchased with arbitrary-waveform generator, $495.



Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311. FAX (206) 548-0322.

Circle No. 361



MS-DOS-Based Test-Generation Software

- *Includes library of 66 instrument drivers*
- *Provides virtual front panels for VXIbus instruments*

ITG/DOS is the version of the vendor's test-generation software that runs on MS-DOS-based personal computers. Previously, the software ran only on the vendor's HP 9000 series systems. The full library of 66 instrument drivers developed for the earlier software works with the DOS version. These drivers permit writing instrument-control programs in the common languages that run under MS-DOS. The drivers for VXIbus instruments provide virtual front panels on the computer's CRT. Because the software produces code that controls the instruments in your system, you need not learn the instruments' native command syntax. $1500; with PC Bus IEEE-488 interface, $1995.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone (800) 752-0900.

Circle No. 362

IEEE-488 Adapter For NeXT Workstation

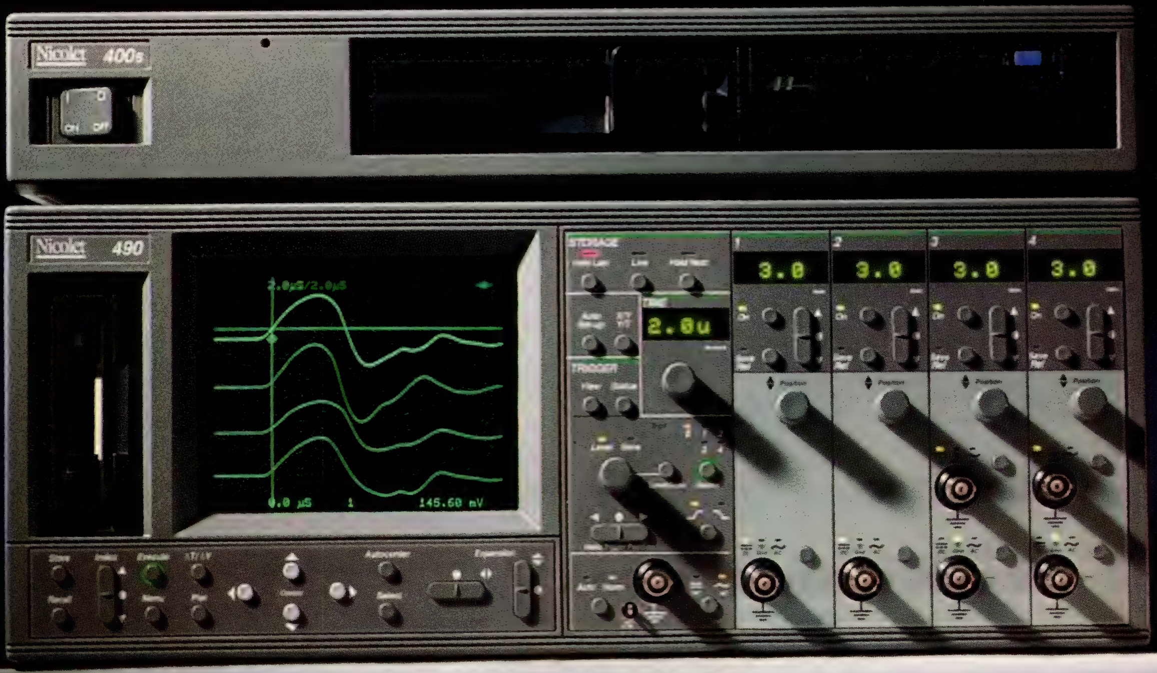
- *Includes a driver that links to Objective C*
- *Allows procedure building via point-and-click interface*

The SCSI488/N is an IEEE-488 interface adapter for the Next Inc workstation. The unit, which attaches to the workstation's SCSI port and transfers data at 900k bytes/sec, permits the workstation to control 14 IEEE-488 devices. Accompanying the adapter is a driver that links to Objective C, the workstation's native software-development language. A point-and-click interface lets you develop instrument-control procedures without writing conventional code. $1495.

IOTech Inc, 25971 Cannon Rd, Cleveland, OH 44146. Phone (216) 439-4091. FAX (216) 439-4093. TWX 650-282-0864.

Circle No. 363

We could run 200 ads like this and still not show you every Nicolet 400 model available.



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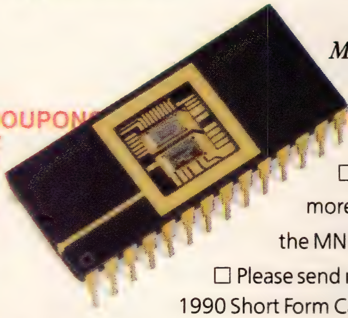
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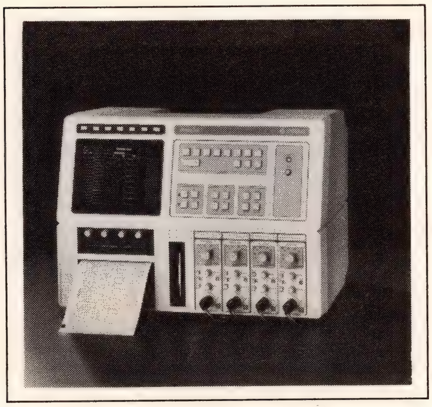

Thermal-Array Chart Recorder

- *Includes scope for previewing data*
- *Stores data on 3½-in. disks for computer analysis*

The WindoGraf is a 4-channel chart recorder that embodies many features usually associated with data-acquisition systems. The thermal-array device records on 100-mm-wide paper without the use of moving pens and handles signals to 500 Hz. A glitch-capture feature ensures that the unit doesn't miss narrow spikes that might not otherwise be sampled at low chart speeds. A built-in 7-in. oscilloscope lets you preview data and thereby save paper. A 3½-in., 1.44M-byte floppy-disk drive enables transferring data to IBM PC-compatible computers for post processing. Plug-in signal conditioning modules allow tailoring of the unit to specific sensor types. $7900; signal conditioners from $250/channel. Delivery, 45 days ARO.

Gould Inc, 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315. **Circle No. 364**

AC/DC Transfer Standard

- *Handles 2 mV to 1 kV from 10 Hz to 1 MHz*
- *Has uncertainty of ±10 ppm*

The 792A ac/dc transfer standard provides enough accuracy and repeatability to permit its use in calibration of the vendor's ac calibrators. Uncertainties are as low as ±10 ppm. After calibration by the NIST (National Institute of Standards and Technology), uncertainty is ±5 ppm. The transfer standard handles voltages from 2 mV to 1 kV and frequencies from 10 Hz to 1 MHz. The unit stabilizes in as little as 30 sec, compared with as much as 30 minutes for a traditional thermal voltage converter. Full-scale output of the sensor is 2V, compared with 7 to 10 mV for thermocouples. The larger output permits making transfers with a DVM rather than a null meter. $19,950. Delivery, eight weeks ARO.

John Fluke Mfg Co Inc, Box C9090, Everett, WA 98206. Phone (800) 443-5853. TWX (910) 445-2943. **Circle No. 365**

Philips Test and Measurement Building TQIII-1, 5600 MD Eindoven, The Netherlands. Phone local office. **Circle No. 366**

IBM PC/AT-Based Waveform Synthesizer

- *Outputs 12-bit analog data at 50 nsec/point*
- *Can also act as 16-channel TTL pulse generator*

The WSB-100 waveform synthesizer plugs into a 16-bit I/O slot in an IBM PC/AT or a compatible PC. The board stores digitized analog waveforms in 32k bytes of RAM and recreates them at rates from 50 nsec/point to 10^7 sec/point. You can connect multiple boards in a master/slave configuration to obtain deeper memory. The board accepts external clock and trigger signals, runs waveforms for a predetermined number of cycles, and can

SCSI INSTRUMENTS

```
> Display trace memory   [in structured format]
Enter starting addr(Hex): 0

0001:    Arbitration /80
0003:    Select w.ATN /C0
0006:       Message-Out/C0(Identify)
0007:       Command /12(Inquiry) 00 00 00 30 00
000D:          Data-In /00 00 01 01 29 00 00 00 43 4F 4E 4E 45 52 20 20
001D:                   43 70 33 34 30 20 28 34 30 6D 62 20 33 2E 35 29
002D:                   2D 30 34 20 42 30 31 33 54 42 20 20 20 20
003B:       Status  /00
003C:       Message-In /00
003D: Bus free
003F:    Arbitration w.ATN /80
0041:    Select w.ATN /C0
0044:       Message-Out/C0(Identify)
0045:       Command /08(Read) 00 00 10 01 00
004B:       Message-In /04(Disconnect)
004C: Bus free
004E:    Arbitration /40
0050:    Reselect /C0
0052:       Message-In /80(Identify)
0053:          Data-In /00 00 00 00 12 34 56 79 12 34 56 7A 12 34 56 7B
0063:                   12 34 56 7C 12 34 56 7D 12 34 56 7E 12 34 56 7F
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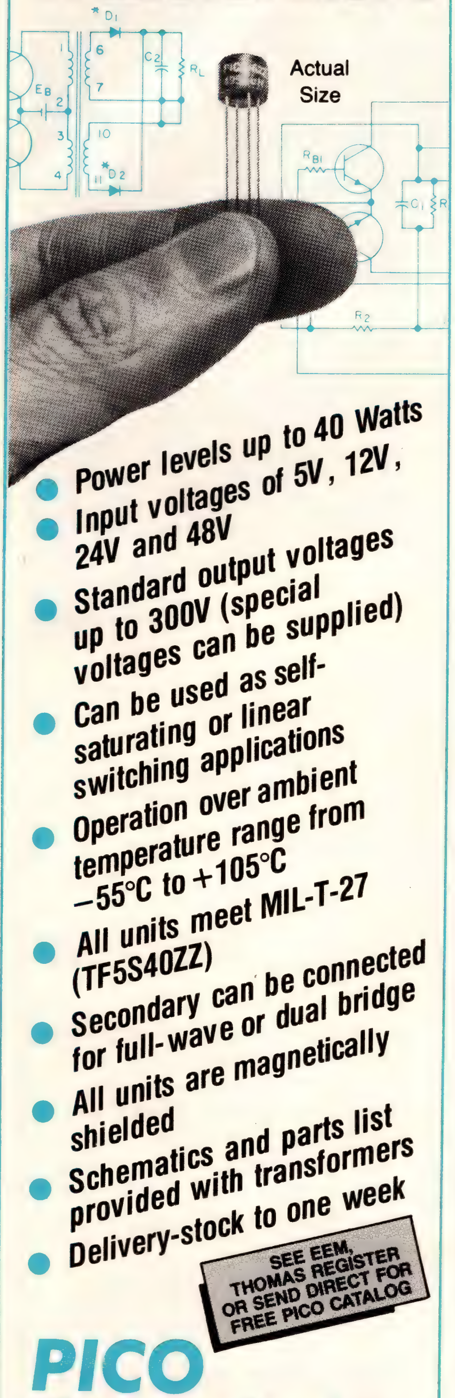

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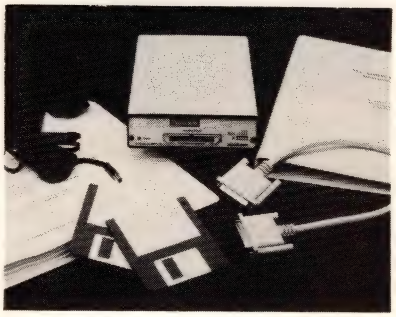
pause between cycles. With an analog-output module, the board replicates stored waveforms with 12-bit resolution. A digital-output module lets you use the board as a 16-channel pulse generator with TTL-compatible outputs. 10-MHz version, $795; 20-MHz version, $995; digital output, $75; analog output, $295.

Qua Tech Inc, 478 E Exchange St, Akron, OH 44304. Phone (216) 434-3154. FAX (216) 434-1409. TWX (510) 101-2726.

Circle No. 367



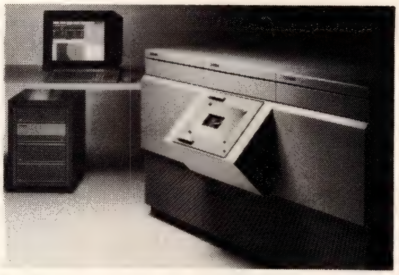
Data-Acquisition Unit For Macintosh Plus, SE, And II

- *Connects to computer's SCSI port*
- *Takes 28,000 12-bit samples/sec*

The SCSI-8AIN data-acquisition and control unit mounts externally to a Macintosh PC and connects to the computer via its SCSI port. The unit contains a 12-bit ADC with a 14-µsec conversion time and 0.02% accuracy. A multiplexer with eight differential inputs and an instrumentation amplifier with DIP-switch programmable gains of 1, 10, 100, 200, and 500 precede the ADC. The unit transfers data to the Macintosh at 57.6k bytes/sec (28,800 samples/sec). Included with the unit is calibration and test software as well as I/O software callable from Lightspeed and Macintosh Programmers' Workshop (MPW) C, MPW and Turbo Pascal, MPW and Absoft Fortran, and QuickBasic. $790.

MetraByte, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (508) 880-3000. FAX (508) 880-0179.

Circle No. 368



IC Evaluation System

- *Allows vectors 512k bits deep*
- *Has 384 I/O channels with ±250-psec timing accuracy*

IC evaluation systems in the HP 82000 series now allow a vector depth of 512k bits. The systems offer an X Window-based user interface, tester/pin architecture, clock rates of 50 and 200 MHz, and channel counts as high as 384. Edge-placement accuracy is ±250 psec. An enhancement to the systems' pattern-generation capabilities lets you obtain the following patterns with a few clicks of a mouse: walking ones and zeros, counters, checkerboard, complement, repeated patterns, and pseudorandom patterns. From $70,000. Delivery, 16 weeks ARO.

Hewlett-Packard Co, 19310 Pruneridge Dr, Cupertino, CA 95014. Phone (800) 752-0900.

Circle No. 369

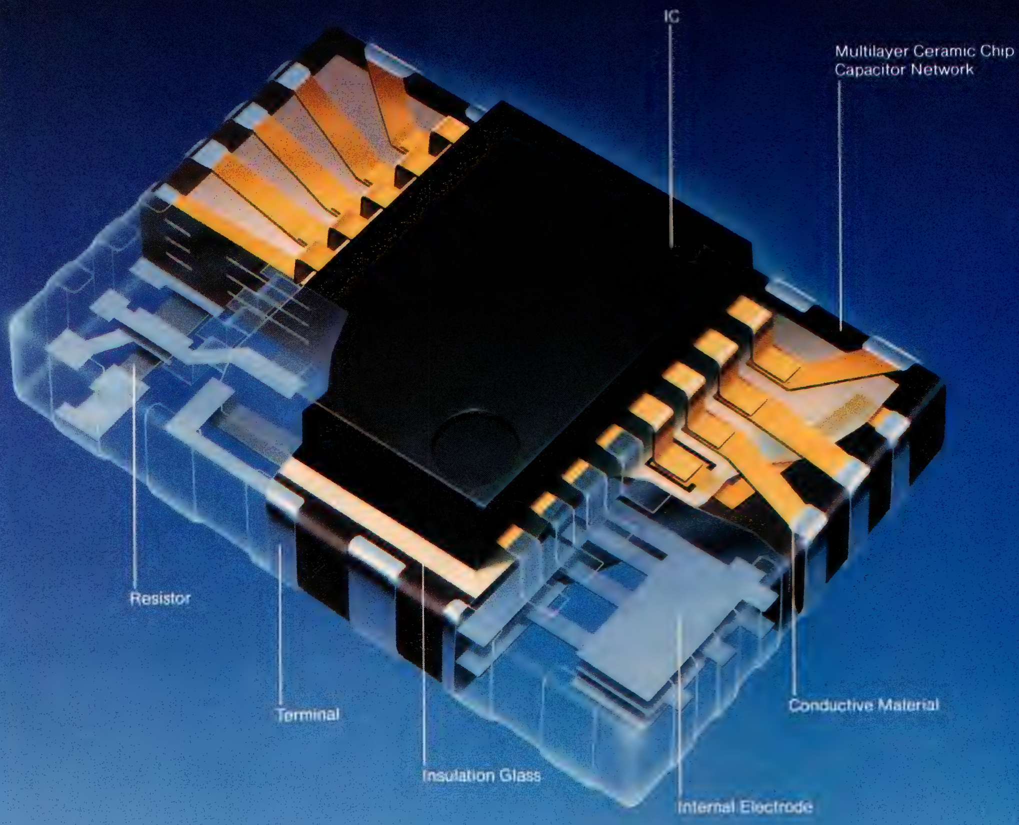
Waveform Storage And Display Software

- *Stores 1M point/sec in extended memory*
- *Displays 71k points/sec*

Snap-Stream V2.5 is a software package for the IBM PC family that controls the acquisition, plotting, and storage of data. With a hard disk of sufficient capacity, the software can store 10^9 data points. In a 25-MHz, 80386-based PC, Snap-Stream V2.5 can write data to extended memory in streaming mode at 1M sample/sec. On the same type of machine, it will store data on a hard disk at 88k samples/sec or in a RAMdisk at 200k samples/sec.

16+16+1=1

TDK Multilayer Hybrid Circuit



TDK Multilayer Composite Chip Technology Adds Up To New Flexibility In Your Circuit Design.

TDK Corporation, the world leader in SMD super integration, has achieved a true breakthrough with the development of an 8.5 x 7.0 x 2.4mm (0.33 x 0.28 x 0.09 in.) equalizer amplifier circuit. This minute multilayer composite circuit integrates 16 capacitors, 16 resistors, and 1 IC—ALL ON 1 CHIP!

TDK's vast experience in ferrite, ceramic dielectric, resistive and conductive materials technology combined with advanced fine pattern thick-film printing and simultaneous sintering technology, results in true functional modules—single chips with complete circuit blocks.

These ready-for-mounting chips allow a big reduction in the number of devices per board, giving you greater flexibility in your circuit designs.

Find out how TDK SMDs can bring value-added efficiency to your production line. Call or write TDK for our FREE SMT CATALOG today.

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Simplifying High Density Placement TDK Surface Mount Devices

Multilayer Ceramic Chip Capacitor

C1608 (CC0603)
C2012 (CC0805)
C3216 (CC1206)
C3225 (CC1210)
C4532 (CC1812)
C5650 (CC2220)
C: 0.5pF ~ 1.5μF

Large-Capacitance Multilayer Ceramic Chip Capacitor

HC8050
HC1063
HC1280
HC1612
TC: +20, −30%
(−25 ~ +85°C)
C: 1 ~ 47μF

Multilayer Ceramic Chip Capacitor Network

MCN7575
TC: COH, 1 ~ 100pF
SL, 10 ~ 1,000pF
TC: −1,000,
+350ppm/°C
(12 capacitors)
Class II,
100 ~ 470,000pF
(12 capacitors)

Multilayer Chip Inductor

MLF2012
L: 0.047 ~ 33μH
MLF3216
L: 0.047 ~ 33μH
MLF3225
L: 39 ~ 220μH

Multilayer Chip LC Trap/IFT

MXT4532
MXT5050
F: 700kHz ~ 10MHz
Tolerance: ±3%
MIA4532
F: 455kHz
MIF4532
F: 10.7MHz

Multilayer Chip Transformer

MTT4532
MTT5050
L: 10 ~ 200μH

Multilayer Chip LC Filter

MXF3535H, B, L, D
MXF4532H, B
MXF5050H, B, L, D
HPF, BPF, LPF,
Delay Line

Micro Chip Inductor (Wound Micro Chip Inductor)

ACL3225S
L: 0.01 ~ 1,000μH

Micro Chip EMI Filter

ACF453218
Attenuation: 25dB min.
F: 4.5 ~ 650MHz

Leadless EMI Filter (Wound Chip EMI Filter)

NLL4532
C: 33pF ~ 100,000pF
L: 1μH ~ 220μH

Leadless Inductor/ Power-Line Leadless Inductor (Wound Chip Inductor)

NL322522
NL453232
NL565050
NLF453232 (Shielded)
L: 0.01 ~ 10,000μH
(15 ~ 450mA)
NLC322522
NLC453232
NLC565050
L: 1.0 ~ 1,000μH
(60 ~ 1,800mA)

Leadless LC Trap (Wound Chip LC Trap)

NLT4532
F: 630kHz ~ 13MHz
Tolerance: ±2%
Attenuation: 20dB min.

Leadless Line Choke (Wound Chip Line Choke)

SF MR820
SF M0520
SF M1010
Inductance: 0.8 ~ 10μH
Rated current: 1 ~ 2A

Ferrite Chip EMI Suppressor

ACB201209
Zo: 7, 10, 11Ω
ACB321611
Zo: 19, 26, 31Ω
ACB322513
Zo: 31, 52, 60Ω
ACB453215
Zo: 70, 120, 125Ω

NTC Chip Thermistor

NTCCS2012
NTCCS3216
R typical:
1.0 ~ 150kΩ at 25°C
Temp. Range:
−25 to +85°C

Ceramic Chip Filter • 10.7MHz

CEF1070
F: 10.7 ±0.03 ~
0.12MHz

SM Pulse Transformer

CPT6 x 6
L: 10 ~ 100μH
Winding ratio
N_1:N_2; 1:1
CPT10 x 10
L: 100 ~ 1,000μH
Winding ratio
N_1:N_2:N_3; 1:1:1

SM Active Delay Line

SAD
Delay time: 20 ~
250nsec.

SM Transformer/ Inductor

EE5 **EE12**
ER9.5 **ER11/5**
ER14.5/6 **T2**

SM Step-up Inductor (Unimorph Piezoelectric Buzzer)

OL3.3 x 1.6
OL3.3 x 2.1

CIRCLE NO. 160

Digital Signal Processing

DSP Development Tools and Standalone Systems from Ariel

For the IBM PC:

DSP-16 • A complete TMS32020 or TMS320C25 Development System on a single board, with 16-bit 2 channel data acquisition of up to 50 kHz per channel.

PC-C25 • The lowest cost full speed TMS320C25 based card available. Just $595 with parallel and serial I/O, 14 bit analog I/O is just $95!

DSP-56 • Integer DSP development system based on the Motorola 56000 DSP chip with two channel 16 bit analog I/O, compatible with Ariel's Bug-56.

PC-56 • A new, low-cost DSP card based on Motorola's fast DSP56001. Full speed 24 bit DSP for $595! Parallel and serial I/O standard. Available with 14-bit analog A/D, NeXT compatible DSP port and microphone preamp.

BUG-56 • Fast, efficient symbolic debugger for the PC-56 and DSP-56. Macros, windows, the works. Also available: Assembler/Simulator, C Compiler and TMS320 Code Converter.

DSP-32C • Floating Point DSP development system with true 16 bit analog I/O based on AT&T's 32 bit DSP32C chip.

PC-32C • Low cost floating point coprocessor based on AT&T's DSP-32C standard with parallel and serial I/O.

SDI • A complete, 2 track 16 bit digital audio recorder with advanced editing capabilities. Real-time 50 kHz stereo I/O using any PC.

SYSid • Comprehensive acoustic test instrument. Developed by Bell Labs for quick and accurate measurements.

PC-FFT • Fast FFT's on a single card.

ASM-320 • The fastest TMS320 Assembler.

PDS-320 • Deluxe TMS320 Program Development.

FFT-320 • 256 and 1024 point TMS320 FFT Subroutines. Real-time demo program too.

FIDAS • Digital FIR and IIR Filter Design with real time implementation on the DSP-16.

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Telex: 4997279 ARIEL
DSP BBS: 201-249-2124

Ariel

CIRCLE NO. 181

When plotting, data acquisition and storage can proceed at 71k samples/sec. The software supports simultaneous acquisition of 80 waveforms and simultaneous display of 32 waveforms. The vendor supplies five compatible analysis packages. $495.

HEM Data Corp, 17336 Twelve Mile Rd, Suite 201, Southfield, MI 48076. Phone (313) 559-5607. FAX (313) 559-8008. **Circle No. 370**

7.1-GHz Portable Spectrum Analyzer

- *Has resolution bandwidth of 10 Hz to 3 MHz*
- *Displays ROM-based help screens*

The 497P portable spectrum analyzer covers 100 Hz to 7.1 GHz with a resolution bandwidth that you can set from 10 Hz to 3 MHz. Frequency-measurement accuracy is 1 ppm. Frequency instability is <5 Hz at 1 GHz. At 1 GHz, phase noise is −105 dBc/Hz (dB with respect to carrier level per Hz). Dynamic range is 90 dB. Sensitivity is −134 dBm from 1 MHz to 1.8 GHz. A series of ROM-based help screens assists users who aren't familiar with the instrument. $26,250. Delivery, six weeks ARO.

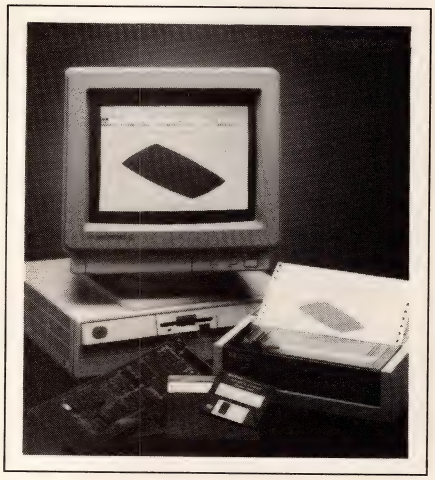
Tektronix Inc, Box 500, M/S 58-183, Beaverton, OR 97077. Phone (800) 835-7732; in OR, (503) 235-7315. **Circle No. 371**

IBM PC-Based Data-Acquisition System

- *Applications software allows linking of C programs*
- *Makes X-Y plots and graphs data vs time*

The CODAS (computer-based oscillograph and data-acquisition system) is a hardware/software system for the IBM PC family. Version 5.2 lets you customize the software by linking programs written in C. By starting with the CODAS software, you avoid having to write routines that control data acquisition, display, and storage. The software generates on-screen and hard-copy plots of data vs time or of one variable vs another. Other built-in functions include determining the area bounded by a curve; the maximum amplitude excursion of a plot; the plot's instantaneous rate of change, the rate of change of a line connecting two points; and the rate of change of a best-fit line between two points. $2790.

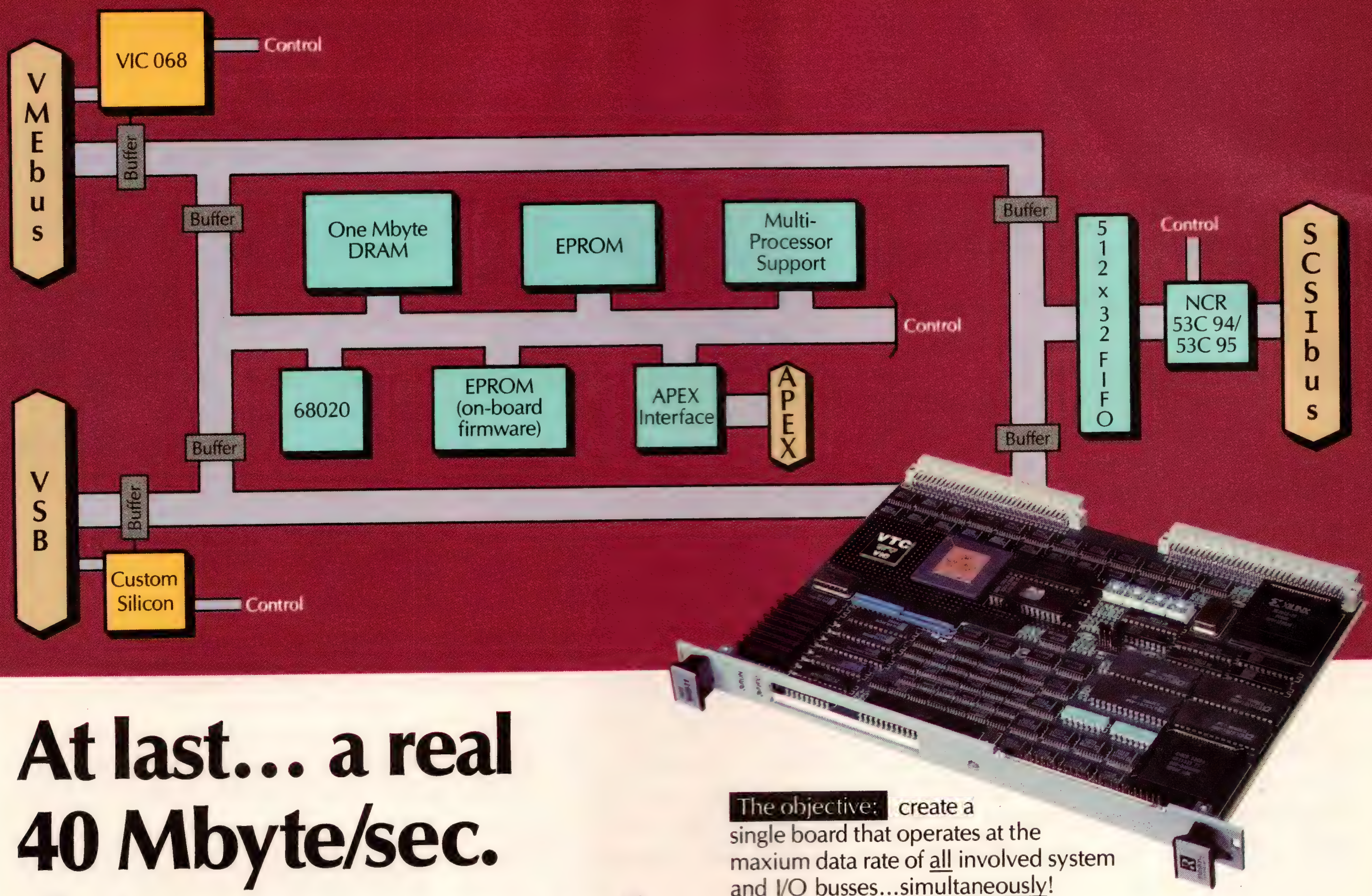
Dataq Instruments Inc, 825 Sweitzer Ave, Akron, OH 44311. Phone (800) 553-9006; in OH, (216) 434-4284. **Circle No. 372**



PC-Based 50-MHz Logic Analyzers

- *Handle TTL, CMOS, and ECL signals*
- *Handle 32 or 16 (expandable to 32) channels*

The ATL1500 series logic analyzers are for the IBM PC bus. There are two versions—one with 32 channels; the other with 16 (expandable to 32). Both units operate at 50 MHz, and both accept TTL, CMOS, and ECL logic levels. In fact, you can set the levels from −6.35 to +6.35V in 50-mV increments. You can qualify triggering on bytes or words. Qualification can be based on inequalities as well as on data matches. The units provide 2-level sequential triggering and 15 counts of event and event-transition de-



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- Sustained 5 Mbyte/sec. transfer rate across the SCSI bus
- A full master/slave VSB interface with its own sustained 30 Mbytes/sec. DMA transfer rate
- 68020 Microprocessor
- 1 Mbyte Quad-ported DRAM
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Commercial through Mil-Spec

Radstone offers an entire family of SCSI interface boards for applications from commercial through full Mil-Spec. Plus the industry's best selection of commercial, ruggedized and military VME processor, memory, communications, I/O and controller boards, development systems and software. Radstone has your VME system solution now. Call us for the details.

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France 'Miniparc,' 6 avenue des Andes, 91940 Les Ulis, (1) 64.46.04.03
Germany Bahnhofstraβe 38, D-6090 Rüsselsheim (0 61 42) 6 80 04

RADSTONE
TECHNOLOGY

CIRCLE NO. 174

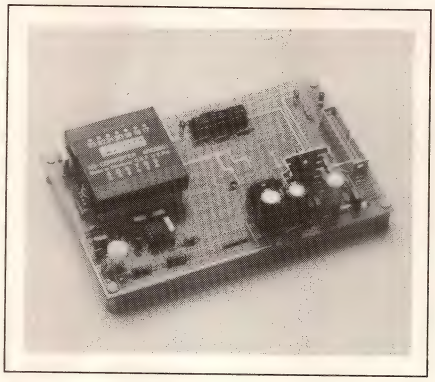
lays. The accompanying software permits timing and data displays; data searches; horizontal magnification; and disk storage of configuration-, reference- and acquired data. 16 channels, $495; 32 channels, $695.

AimTek Corp, 1720 S Orange Ave, Suite 304A, Orlando, FL 32806. Phone (407) 425-6246.

Circle No. 373

Data-Acquisition Board

- *Includes 25-bit integrating ADC*
- *Supplies data through Centronics interface*



The Model 5651 control board uses the vendor's 25-bit integrating ADC module, the Model 5601. The µP-based board, which receives power from a wall-mounted plug-in transformer, provides timing, control, reference, and offset signals for the ADC and a convenient method of connecting analog inputs. It also permits you to interface the ADC to a Centronics-compatible parallel port on an IBM PC or a compatible computer. The ADC has input ranges of 0 to −5V and of ±2.5V. It offers nonlinearity of 0.0001% and a typical temperature coefficient of 0.5 ppm/°C. The ADC makes a 14-bit conversion in 10 msec and a 25-bit conversion in 20 sec. Model 5651 control board with the ADC, $750.

Prema Precision Electronics Inc, 4650 Arrow Hwy, Suite E-5, Montclair, CA 91763. Phone (800) 441-0305; in CA, (714) 621-7292. FAX (714) 625-2098.

Circle No. 374

Prema GMBH, Robert Koch Strasse 10, D-6500 Mainz 42, West Germany. Phone (06131) 5062-16. FAX (06131) 5062-22.

Circle No. 375

In-Circuit Programming Software

- *Supports 30 more devices than earlier version*
- *Allows programming of 32 boards at once*

The 4100 and 4400 in-circuit programmers now come with version 3.0 of the vendor's software. The 4100 programs eight boards at once; the 4400 programs 32. Both systems

Dynamic 320 Series Tactile Pushbutton Switches

Offering flexibility for single key or keyboard layouts.
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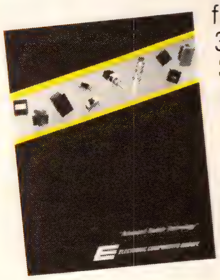

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CIRCLE NO. 171

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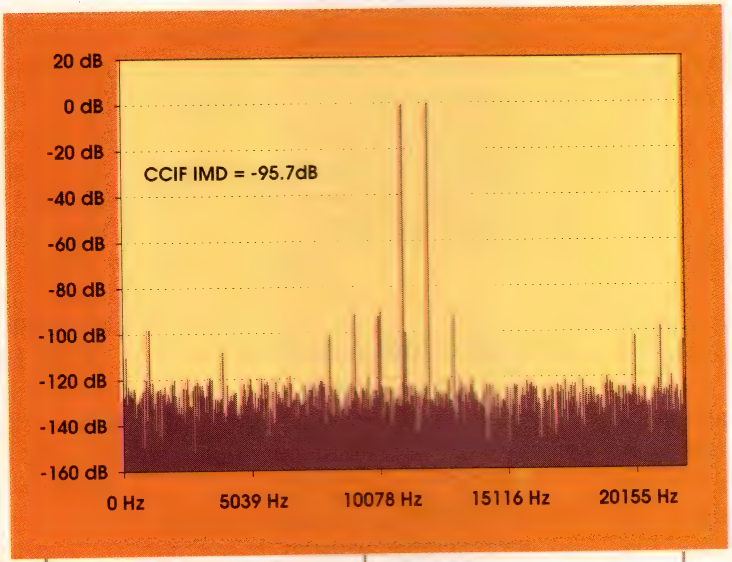

The World's First Dual Monolithic 18-Bit DAC

Introducing PCM1700P, the newest member in Burr-Brown's growing family of high performance digital audio D/A converters. Its price and performance are made to match the brilliance of your next audio design.

- –92dB max THD + noise
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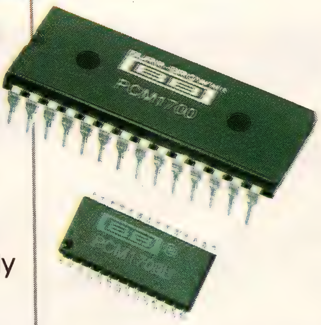
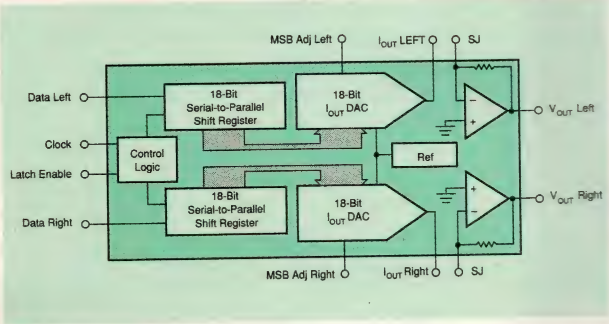
If your design requires the best the world has to offer, design in the world's most brilliant audio DAC, PCM1700P.



For complete details on Burr-Brown's new PCM1700P and its family of digital audio solutions, contact your local Burr-Brown office.

Burr-Brown Corp.
P.O. Box 11400
Tucson, AZ 85734-1400
U.S.A.
FAX (602) 741-3895



BURR-BROWN®

CIRCLE NO. 179

handle EPROMs and EEPROMs to 4M bits as well as microcontrollers. Compared with the previous version, the new software supports 30 more devices from 12 vendors. It also includes a batch language and allows use of multiple programming algorithms in a single pass. 4100, from $10,700; 4400, from $16,700.

Data I/O Corp, Box 97046, Redmond, WA 98073. Phone (206) 881-6444. FAX (206) 882-1043.

Circle No. 376

22-Bit Data-Acquisition Board

- *Plugs into IBM PC bus*
- *Accepts eight single-ended or 16 differential inputs*

The Adio-100 is a 22-bit data-acquisition card. Not only does the board plug into the IBM PC bus, it also conforms to Ampro Computer Inc's Little Board format. The board includes a 22-bit integrating ADC; an analog multiplexer, which is software configurable to accommodate eight differential or 16 single-ended inputs; 24 bits of digital I/O interface; five 16-bit up/down counters that operate to 6 MHz; and a 6-MHz frequency source. Also included are 512 bytes of nonvolatile memory that's accessible to the user. The digital output ports are latched and provide readback. $1400.

Control Solutions Inc, 172 Boston Post Rd, Wayland, MA 01778. Phone (508) 358-4666.

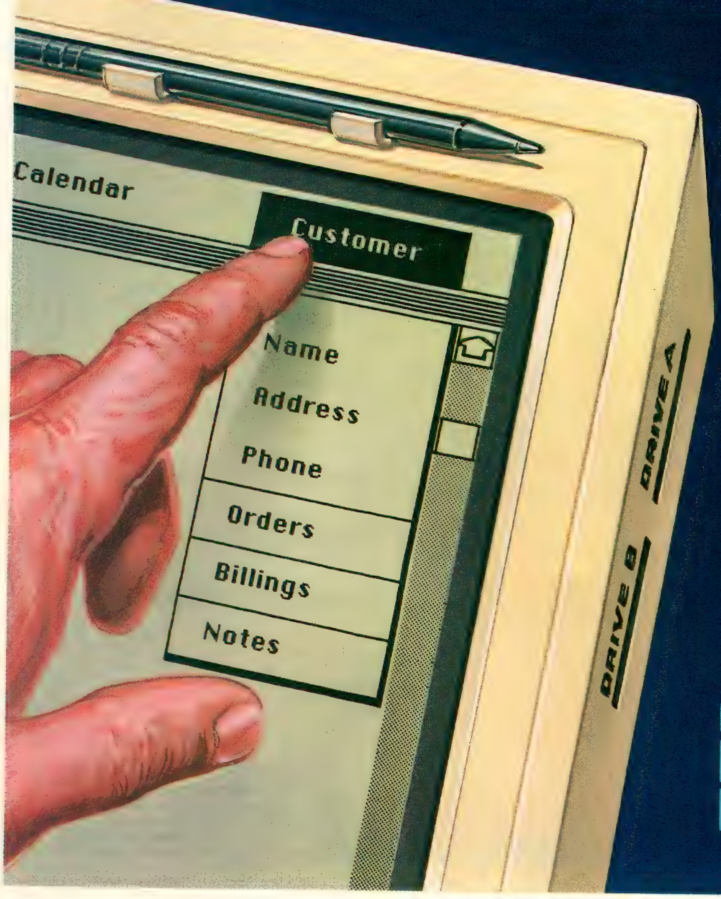
Circle No. 377

DSP Development Tool

- *For prototyping systems that use AT&T WE-DSP32C*
- *Has 64k bytes of zero-wait-state RAM*

The DSP32C is a development tool for prototyping systems based on AT&T's WE-DSP32C DSP chip. The IBM PC/AT plug-in board, which incorporates a 50-MHz WE-DSP32C, includes 64k bytes of zero-wait-state RAM or 256k bytes of one-wait-state RAM. Other features are a clock and a 2-channel analog I/O subsystem with a differential amplifier, a fourth-order low-pass antialiasing filter, a S/H amplifier, a 16-bit ADC, a 16-bit DAC, and a reconstruction filter. The analog subsystem supports simultaneous input and output at 50 kHz. The DSP chip's parallel ports are mapped into the PC/AT's I/O address range. With 64k bytes, $2395; with 256k bytes, $2995.

DSP Design Tools, 4101 Green Pond Rd, Bethlehem, PA 18017. Phone (215) 691-0693. FAX (215) 691-2413. **Circle No. 378**



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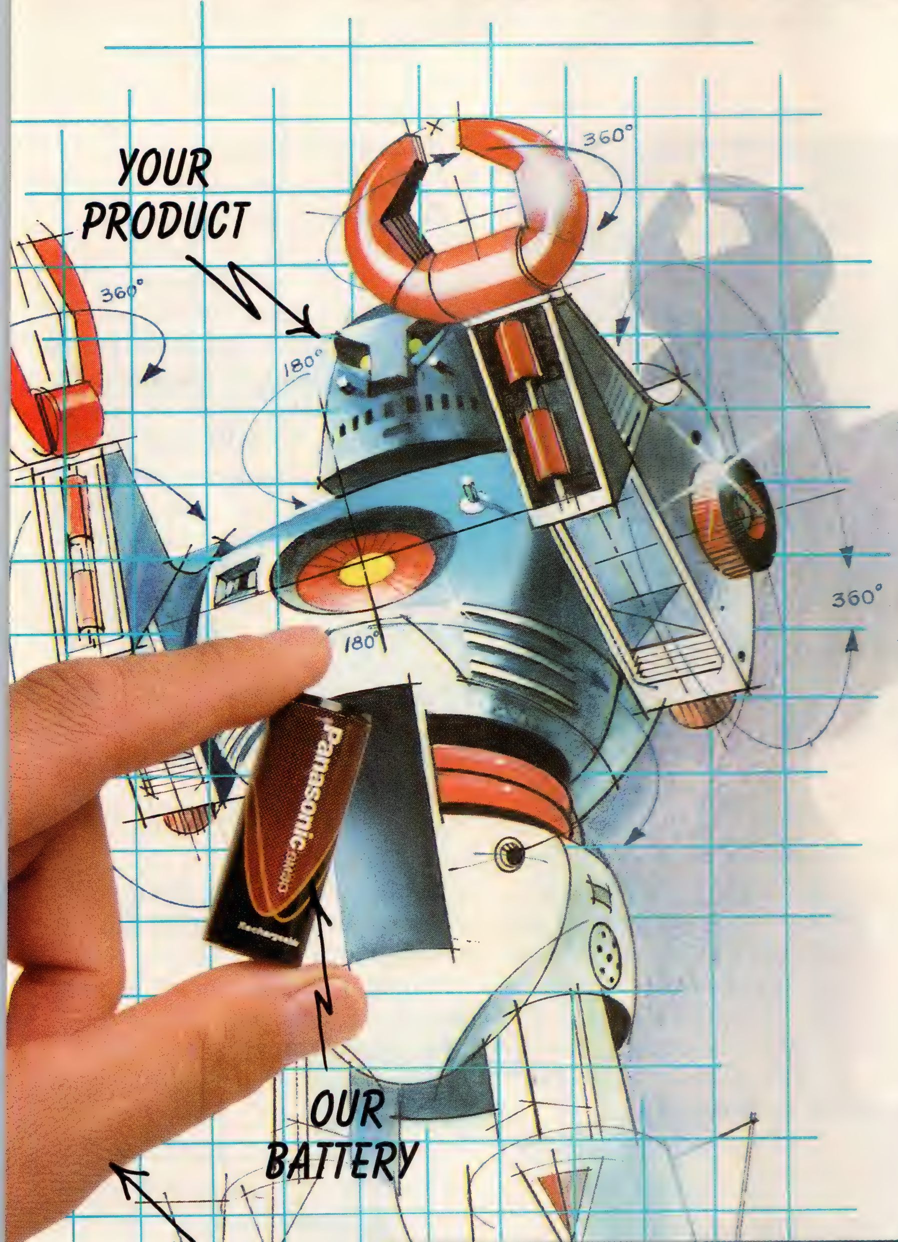
CIRCLE NO. 173

Go ahead, create a monster.



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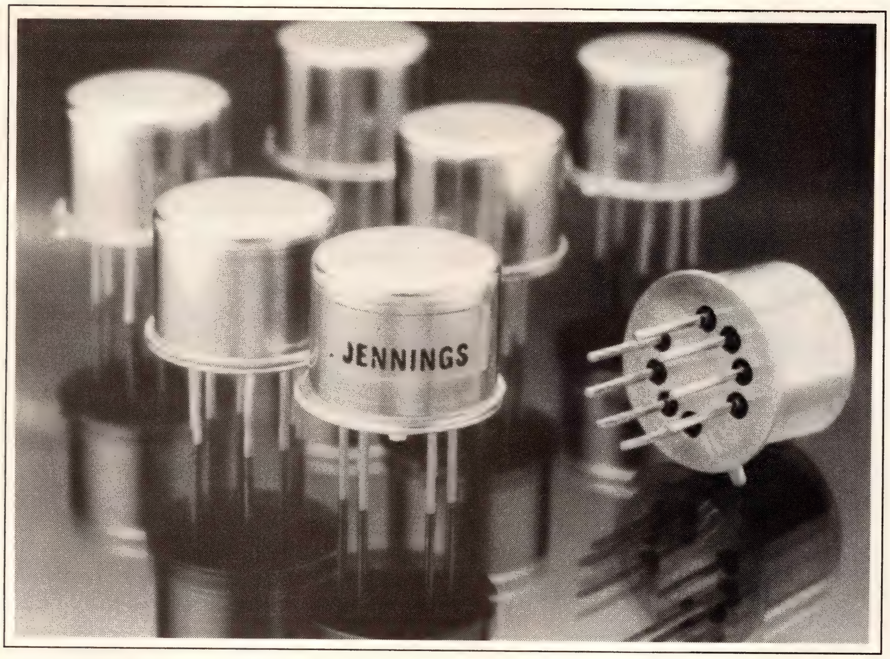


Miniature Relays

- *Come in TO-5 housings*
- *Rated for 0.5A at 28V dc*

Designed for high-frequency applications, TO-5 Series miniature relays have a contact life of 5 million operations at low load levels and 1 million operations for loads of 0.5A at 28V dc. Relay insertion loss at 1 GHz equals <0.1 dB, and VSWR at the same frequency measures 1.21. Input-voltage levels range from 5 to 30V dc. In standard contact arrangement of 2 Form C, the relays are available with either pin- or wire-type leads. $12 to $14 (OEM qty).

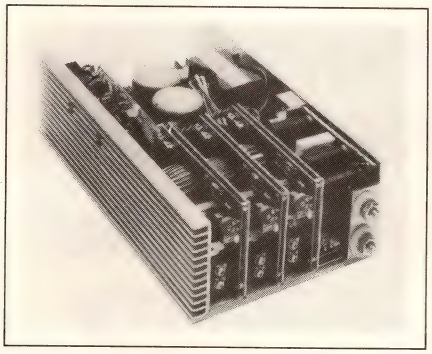
Jennings, 970 McLaughlin Ave, San Jose, CA 95122. Phone (408) 292-4025. **Circle No. 393**

Modular Power Supplies

- *Deliver 6W/in.^{3}*
- *Provide 750W output*

Moduflex M Series open-frame switching power supplies are assembled from off-the-shelf modules. Available in both single- and multiple-output models, the supplies output 400 to 750W and deliver power densities of 6W/in^3. Line and load regulation equals ±0.1 and ±0.2%, respectively. Other features include a switching frequency of 120 kHz, current-mode control, system inhibit, quasiregulated output, and isolated cooling fans. All outputs are fully adjustable and isolated. Overload, short-circuit, and overvoltage protection are standard. Auto ranger for continuous input operation, power-fail monitor, and covers are available as options. From $478.

Deltron Inc, Box 1369, North Wales, PA 19454. Phone (215) 699-9261. TWX (510) 661-8061. **Circle No. 394**

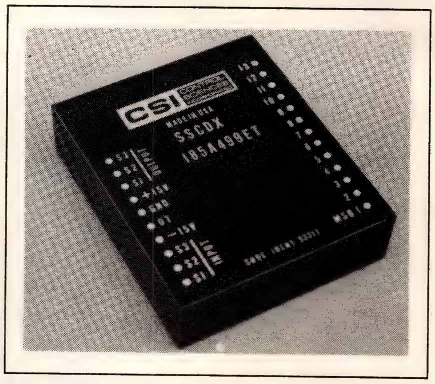


Rectifier Diodes

- *Handle 30A currents*
- *Reverse recovery times equal 100 nsec max*

The BYT230PI family is a series of seven double-diode devices that can handle peak repetitive-reverse-voltage levels ranging to 1000V. Each diode has an average current rating of 30A max, which develops a forward drop of 1.8V when the juncture temperature is 100°C. Switching off at 50V/μsec when operating at 1A yields a reverse recovery time of <100 nsec. The modules have a 2.5-kV-rms isolation rating, and they connect directly to a heat sink. Measuring 1×1.5 in., the solderable, screw and push-on connector versions measure 0.5 and 0.8 in. high, respectively. Gld 11 (1000).

Philips Components, Box 218, 5600 MD Eindhoven, The Netherlands. Phone (40) 724324. **Circle No. 395**



Differential Transmitters

- *Provide a 3-VA output*
- *Available in commercial or military temperature ranges*

Series 185A400 solid-state converters accept synchro or resolver analog inputs and a 13-bit digital input.

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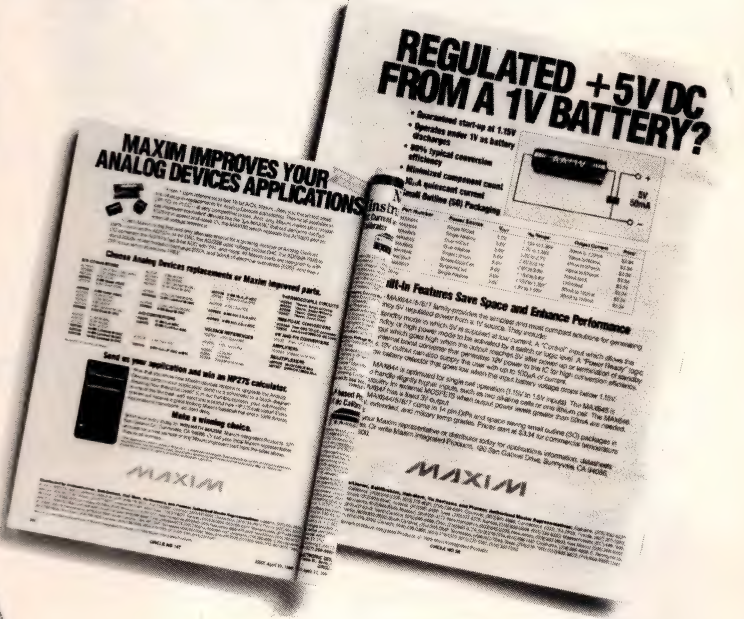
Mike Dikas believes in the complementary roles of EDN Magazine and EDN News Editions.



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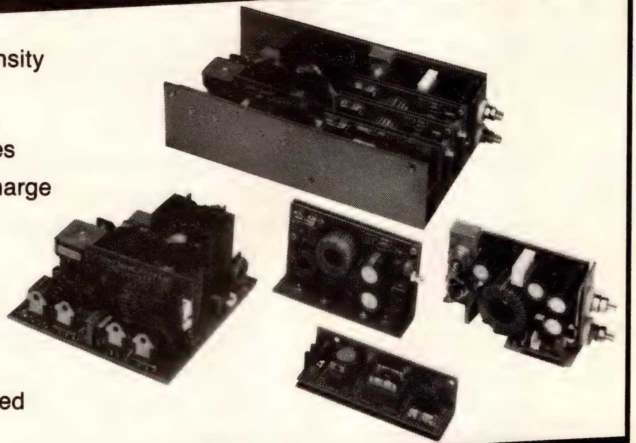

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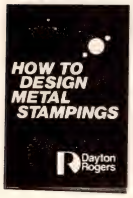

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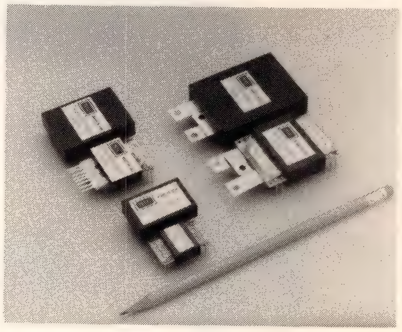
CIRCLE NO. 177

The units compute the difference between the analog and digital inputs and provide a buffered 3-VA synchro or resolver output signal whose value is proportional to the input angular difference. The devices are designed to digitally offset, zero, or rescale synchro signals in radar, navigation, and control applications. Housed in a standard 2.6×3.1×0.82-in. module, the transmitters are available in commercial or military temperature ranges. Models are also available that include MIL-STD-883B processed ICs and established-reliability passive components. From $795. Delivery, stock to 10 weeks ARO.

Control Sciences Inc, 9509 Vassar Ave, Chatsworth, CA 91311. Phone (818) 709-5510.

Circle No. 396



Planar Magnetics

- *Operate at 1 MHz*
- *Rated at 500W*

These high-frequency planar transformers and inductors are built to MIL-T-27E, grade 5 and 6 specifications. Designed for 0.1- to 1-MHz operation in PWM or resonant-topology converters, the units are available in three packages, each of which can deliver multiple outputs. T-050 units measure 1.35×0.85×0.33 in. and are rated at 75W. T-125 models are rated at 200W and measure 1.5×1.25×0.38 in., and T-250 versions measure 2.15×1.7×0.5 in. and are rated at 500W. Features include either pretooled laminated boards or copper-stamping

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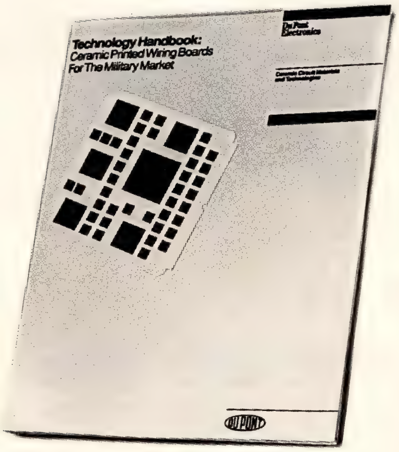

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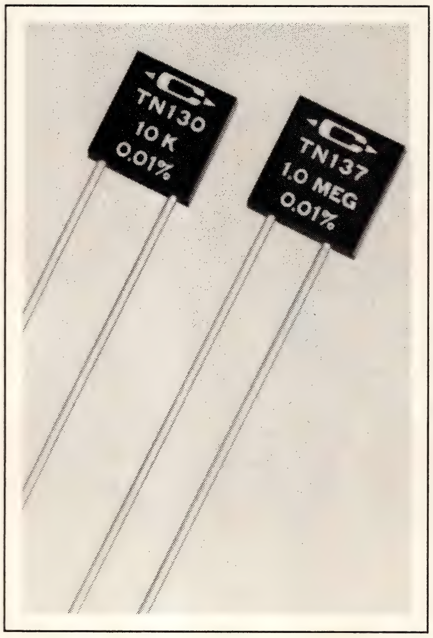
Multisource Technology Corp, 393 Totten Pond Rd, Waltham, MA 02154. Phone (617) 890-1787. FAX (617) 890-8011. **Circle No. 397**



Precision Resistors

- *Values range to 1 MΩ*
- *Tolerance of 0.01% available*

Type TN precision resistors are available in values of 1 kΩ to 1 MΩ. Standard tolerance levels range from ±0.01 to ±1%, and tolerance coefficients equal 5, 10, or 20 ppm/°C. These noninductive resistors come in lengths from 0.15 and 0.2 in. and feature a radial lead design to conserve pc-board space. Load-life stability equals 0.003% max/2000 hours at rated load at 70°C. $3.27 (5000) for a 100-kΩ unit with a 0.1% tolerance and a temperature coefficient of 5 ppm/°C. Delivery, eight weeks ARO.

Caddock Electronics Inc, 1717 Chicago Ave, Riverside, CA 92507. Phone (714) 788-1700. FAX (714) 369-1151. **Circle No. 398**

Solid-State Relay

- *Has a 5A load capability*
- *Includes a snubber*

Designed for pc-board mounting, the OACM-UH solid-state relay has an output capability of 5V at 12 to 280V ac at 25°C. This output capability derates linearly to 1.3A at 12 to 280V ac at 80°C. An integral dv/dt snubber network across the output protects against false triggering by restricting the rise of most voltage transients to within acceptable limits. The optically coupled relays feature a 4000V rms input-to-output isolation. Input-voltage levels span a 3 to 15V dc range. Standard relays feature zero-voltage turn on, but random turn-on units are available. The relays are UL recognized, CSA certified, and meet VDE requirements. $3 (OEM qty).

Potter & Brumfield Inc, 200 S Richland Creek Dr, Princeton, IN 47671. Phone (812) 386-1000.
Circle No. 399

Digital Thermometers

- *Accept inputs directly from thermocouples*
- *Feature ±1% accuracy*

Model 95000 Series digital panel-mount thermometers incorporate custom ASICs to produce an accuracy of ±1% and a resolution of ±0.1°. The units accept input directly from thermocouples or Pt100 RTDs (resistance temperature detectors) and display the reading on a 0.56-in.-high, 3½-digit LED readout. Features include complete linearization for RTD inputs, zero and span drifts of <0.005%/°F, and

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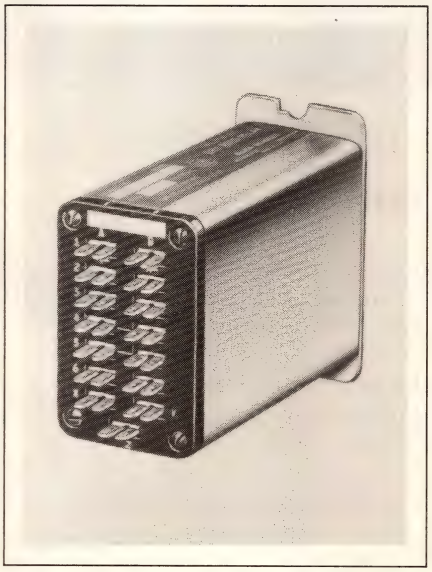
CIRCLE NO. 190

automatic overrange and burnout indication. Housed in a ⅛-DIN case, the thermometers feature 20-turn potentiometers for fine zero and span adjustments and a terminal-strip-type input. Units are available with built-in, dual on/off control points. $123.20.

S-Products Inc, 35 Kings Hwy E, Fairfield, CT 06430. Phone (203) 331-9546. FAX (203) 335-2723.
Circle No. 400



Reed Relays

- *Designed for industrial applications*
- *Feature hermetically sealed contacts*

The units in this line of reed relays are designed for factory-floor industrial applications. They feature hermetically sealed reed-switch contacts. The line includes Type 1610 and Type 1610(L) dry-reed relays with latching designs and as many as eight contacts in NO or NC combinations. Type 1612(L) dry-reed shift registers are available for memory applications, and Type 1617 dry-reed counter units can be interconnected to construct various binary- or ring-counter arrangements. $190 to $350. Delivery, four to six weeks ARO.

Prime Technology Inc, EI&S Div, Box 185, North Branford, CT 06471. Phone (203) 481-5721. FAX (203) 481-8937. **Circle No. 401**

Diode Detectors

- *Feature connectors*
- *Handle 18-GHz signals*

These coaxial, broadband, padded Schottky diode detectors have a flatness of ±1 dB over a frequency range of 2 to 18 GHz. Model ACSP-2644N has a tangential sensitivity of −45 dB and internal 6-dB input attenuation when operating at a 100-μA bias. Model ACSP-2643P offers a −48-dB tangential sensitivity and a 3-dB internal attenuation when biased at −100 μA. Both models are available with SMA connectors at the input and output. Both can be screened to MIL-STD-883 and are designed to handle severe environmental conditions. $165. Delivery, four to six weeks ARO.

Advanced Control Components, Box 4928, Clinton, NJ 08809. Phone (201) 534-6155. FAX (201) 534-5625.
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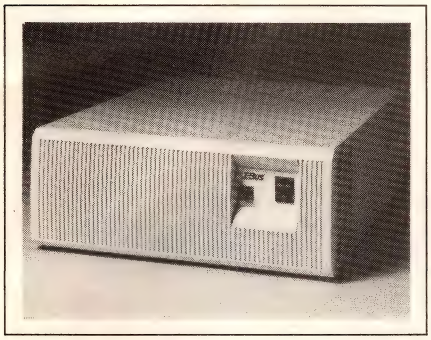


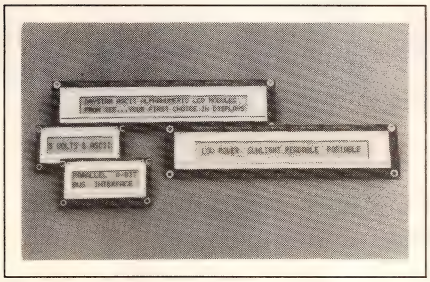
PC Bus Enclosures

- *House single or multiple systems*
- *Come with power supply*

Series 5100T desktop enclosures hold 20 bus cards and feature three power-supply options, triple-fan cooling, and a passive backplane. The units are designed for embedded IBM PC/XT- or PC/AT-compatible applications. You can segment the backplane to accommodate two or more complete systems. The enclosures come with a choice of 200, 270, or 325W power supplies; multiple power connections ensure even power distribution to the backplane. All models are UL, CSA, and TUV approved and meet FCC class A EMI/RFI specifications. A rackmount version is also available. $1435 for a 200W model.

I-Bus, 9596 Chesapeake Dr, San Diego, CA 92123. Phone (619) 569-0646. FAX (619) 268-7863.

Circle No. 403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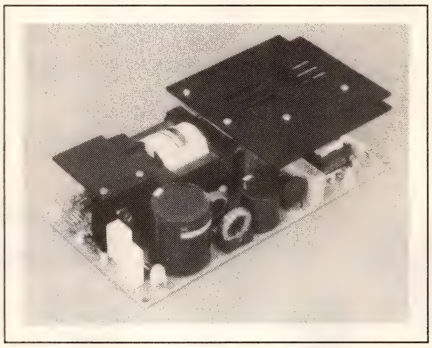
LCD Alphanumeric Modules

- *Offer as many as four line displays*
- *Have 70° viewing angles*

These LCD dot-matrix alphanumeric modules feature onboard controller/drivers that accept and decode ASCII data in a 5×7 format. Units are available with eight, 16, 20, 24, 40, and 80 characters in one, two, three, or four lines. Optional features include 0 to 50°C or −10 to +70°C operating ranges, standard-twisted or super-twist nematic fluids, and electroluminescent or LED backlighting. From $15.40 (100) for a 1×16 model. Delivery, stock to eight weeks ARO.

IEE Inc, Component Products Div, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. FAX (818) 902-3723.

Circle No. 404



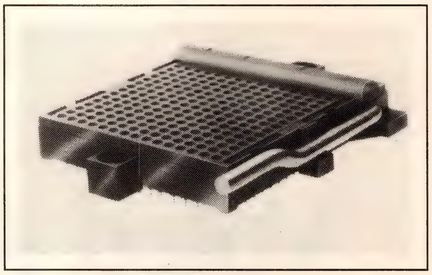
Multiple Power Supplies

- *Feature a universal input*
- *Offer four outputs*

FLU3-100 and FLU4-100 triple-and quad-output supplies feature a 100W capability. Six models provide outputs of 5V in combination with −5, −12, +12, and +24V. All models accept a universal input of 85 to 265V ac or 100 to 370V dc. Efficiency equals 65%, holdup time measures 16 msec, and isolation equals 5300V dc. Soft start and overvoltage protection are standard on the 5V output supplies, and all models have VDE/FCC class B onboard EMI filters and current limiting. Under natural convection conditions, the supplies will operate over a 0 to 70°C range. FLU3-100, $151; FLU4-100, $159.

Power General, Box 189, Canton, MA 02021. Phone (617) 828-6216. FAX (617) 828-3215.

Circle No. 405



Pin-Grid-Array Test Sockets

- *Handle 125°C*
- *Come with normally closed contacts*

These zero-insertion-force, pin-grid-array sockets are designed for test and burn-in applications involving temperatures in the −65 to +125°C range. The socket bodies are molded of heat-resistant PPS, and the normally closed contacts are gold-plated beryllium copper. The sockets feature a stainless-steel cam lever, which ensures positive, smooth contact closure. The sockets' sizes range from 13×13 to 21×21 pins. You can blank off the outer row of pins to accommodate even-number grid patterns. $42.50 to $70 for a 15×15-pin version.

Aries Electronics Inc, Box 130, Frenchtown, NJ 08825. Phone (201) 996-6841. FAX (201) 996-3891.

Circle No. 406

Miniature Inductors

- *Offer 220 μH inductance values*
- *Are surface mountable*

Series 3612 surface-mountable chip inductors offer inductance values of 10 nH to 220 μH. Housed in 1210-type packages measuring only 0.01×0.01×0.09 in., the devices are encapsulated in a wide heat-proof epoxy casing that features wide solder-coated copper terminations. Weighing only 40 mg, the inductors are supplied in 8-mm tape on 7-in. reels of 2000 pieces. £0.1 (100,000).

Citec, Westmead, Swindon SN5 7YT, UK. Phone (793) 487301. FAX (793) 610217.

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CIRCLE NO. 187

Guide To Open-System Interfaces

Issue 3 of the X/Open Portability Guide provides a road map for implementing open systems. It details each interface of the vendor's Common Applications Environment. The complete guide consists of a 7-volume set: Vol 1, XSI Commands and Utilities; Vol 2, XSI System Interfaces and Headers; Vol 3, XSI Supplementary Definitions; Vol 4, Programming Languages; Vol 5, Data Management; Vol 6, Window Management; and Vol 7, Networking Services. Single volumes, $30; complete set, $130.

Prentice Hall, Book Distribution Center, Route 59 at Brookhill Dr, West Nyack, NY 10995.

INQUIRE DIRECT

Pamphlet Presents Digitizing Oscilloscopes

This 18-pg brochure describes Models HP 54502A and HP 54504A 400-MHz-bandwidth digitizing oscilloscopes. In addition to 4-color illustrations, the publication provides specifications, characteristics, and ordering information.

Hewlett-Packard, 4 Choke Cherry Rd, Rockville, MD 20850.

Circle No. 351

Booklet Describes Parallel I/O Boards

The 20-pg brochure, *Interfacing Techniques for 48- and 64-Channel Parallel I/O Boards,* provides a guide to interfacing a variety of real-world sensors to parallel I/O boards. The publication discusses peripherals, including relays and other inductive boards, solid-state relays and LEDs, 7-segment displays, optical isolators, and keyboards and thumbwheel switches. Also included are a 7-segment display look-up table and a sample program for scanning a 4×4 keypad. An application note contains tables and diagrams to explain the decoding process.

Computer Dynamic Sales, 107 S Main St, Greer, SC 29650.

Circle No. 352

Selecting RF Products

RF Selector Guide (SG46/D, Rev 7) presents the most complete listing of the company's standard RF products. Its descriptions of more than 75 new products include many hybrid amplifiers and integrated amplifier assemblies. It also includes an extensive RF transistor cross reference and gives data on power FETs, power bipolar devices, and small-signal products.

Motorola Inc, Literature Distribution Center, Box 20924, Phoenix, AZ 85063. **Circle No. 353**

Two Modes In One Instrument Discussed

This brochure examines the vendor's DTA, a digital timing analyzer that offers both time-ordered and sample modes in one instrument. It describes the high-speed memory that stores as many as 262,000 continuous time-ordered measurements, with no missed intervals, for data rates as high as 20 MHz at a resolution of 50 psec. The 4-color publication illustrates the instrument and provides specifications.

International Test Instruments Inc, 15550-B Rockfield Blvd, Suite 100, Irvine, CA 92718.

Circle No. 354

Looking At Virus-Free Product Development

This engineering study is designed to help software developers provide quality assurance and prevent the unwitting release of computer viruses into their products. Looking at a broad range of techniques, the publication recommends 10 specific measures for avoiding accidental viral releases.

Software Development Council of North America, Box 61031, Palo Alto, CA 94306. **Circle No. 355**

Publication Describes PC Subsets Of FEA Program

This brochure presents PC subsets of the Ansys finite-element-analysis (FEA) program. The publication explains the benefits of using these analysis tools and also lists features, capabilities, hardware configuration, and support services.

Swanson Analysis Systems Inc, Box 65, Johnson Rd, Houston, PA 15342. **Circle No. 356**

Catalog Of Solenoids

This 144-pg catalog (LLS503) details the vendor's line of custom and stock solenoids, including rotary, tubular, low profile, and open frame. Opening with an overview of solenoid theory and fundamentals, the catalog also furnishes an engineer's guide to solenoid selections for spe-

Text continued on pg 324

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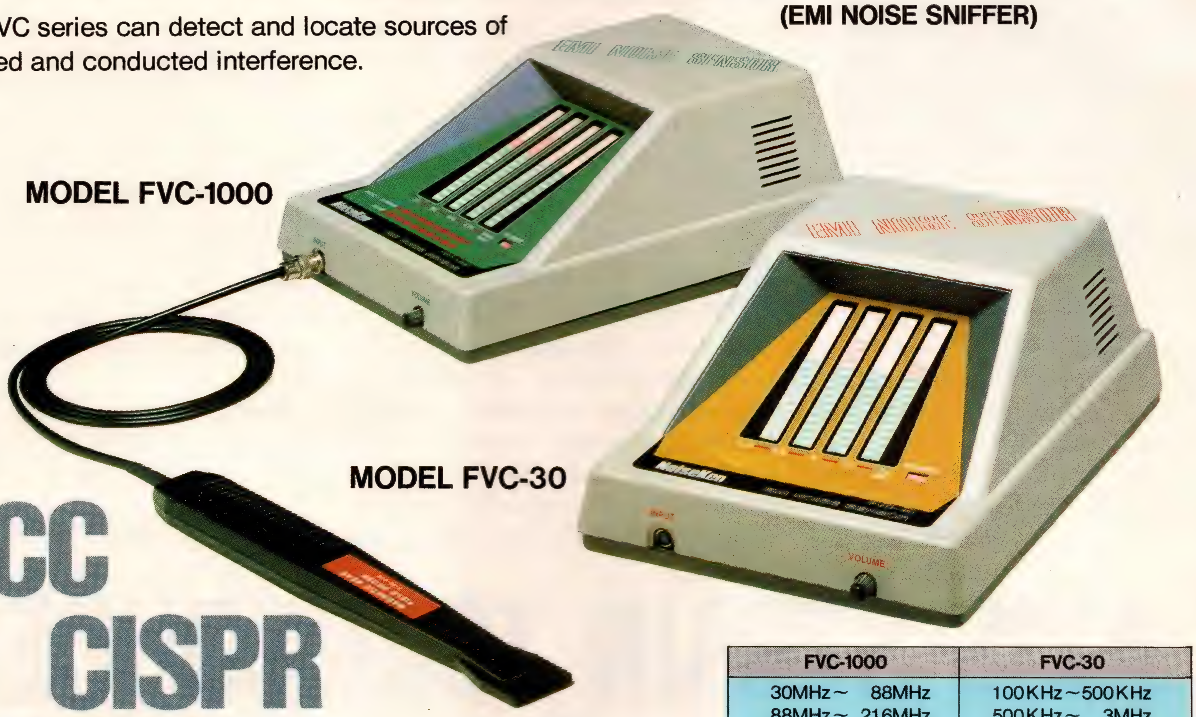

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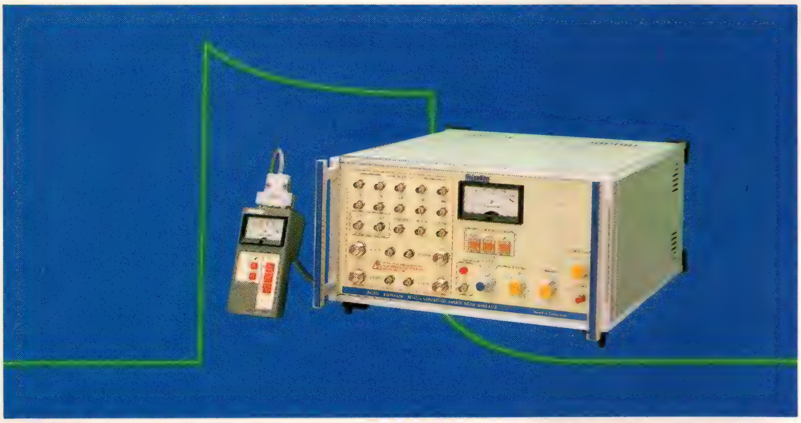

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cific applications. The publication provides construction, operation, application, and specification/performance data.

Lucas Inquiry Management, Box 2813, Torrance, CA 90509.

Circle No. 357

Reference For IOM-2 Bus

This reference guide helps you understand the common architecture for interconnecting circuits used in the ISDN (Integrated Services Digital Network). The document defines the IOM-2 (ISDN-oriented modular) interface, an industry-standard bus for interconnecting telecommunications integrated circuits.

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088.

Circle No. 358

Brochure Features IEEE-488 Bus Products

This 10-pg publication contains a comprehensive line of IEEE-488 bus controllers, extenders, expanders, and auxiliary products. The booklet also describes interfacing tools and hardware for VXI instrumentation. In all, the publication presents more than 40 hardware, software, and accessory items for enhancing IEEE and VXI instrument bus or PC systems.

ICS Electronics Corp, 2185 Old Oakland Rd, San Jose, CA 95131.

Circle No. 359

Catalog Highlights Discrete Semiconductors

A 179-pg catalog of discrete semiconductors presents the vendor's line of surface-mount, power, small-signal, and optoelectronic devices. The publication contains a 68-pg alphanumeric index of cross-reference information, including packaging specifications and outline drawings.

Philips Components, Discrete Products Div, 2001 W Blue Heron Blvd, Riviera Beach, FL 33404.

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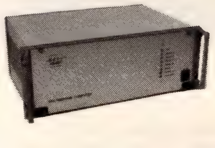

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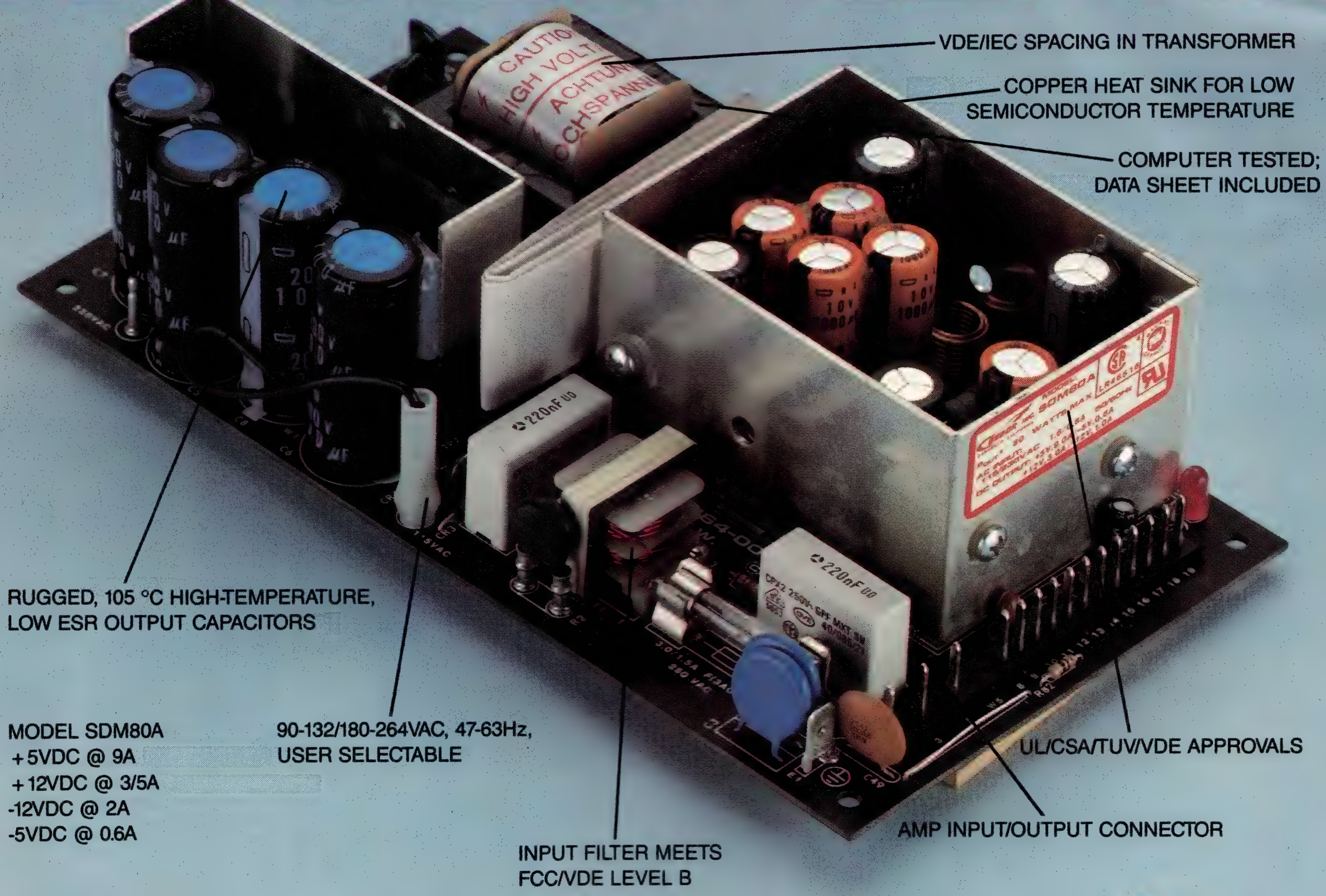
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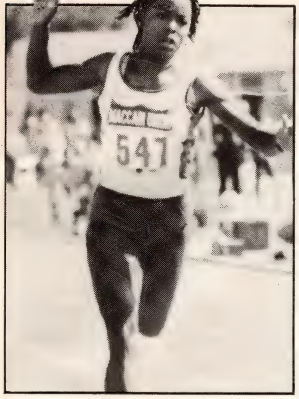

and EDN takes 1st place in readership.

In 1980, the first-ever Chinese Olympic team attends the Winter Games…

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In 1981, the Columbia makes the first space shuttle flight…

and EDN soars – finishing 1st in readership.

In 1982, Lady Diana, Princess of Wales, has her first child…

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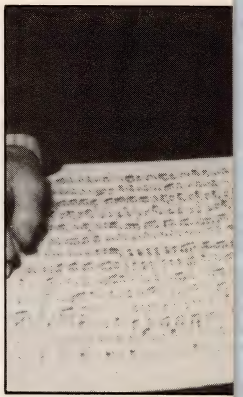
In 1983, the first symp written by Mozart (at a nine) is discovered…



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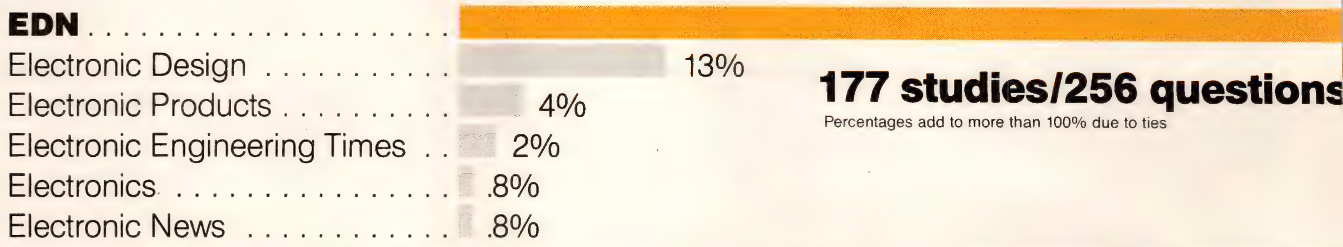
CUMULATIVE WINS –
% of Readership/Reader Preference Wins* 1978–1989 (to date)



177 studies/256 questions

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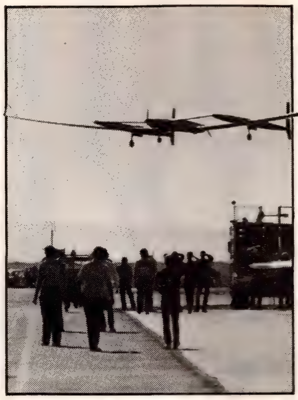

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In 1988, Wrigley Field in Chicago lights up for the first time…

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4	3	2	NOT INCL.
2	4	3	6
2	3	4	NOT INCL.
2	NOT INCL.	3	NOT INCL.
3	2	4	5

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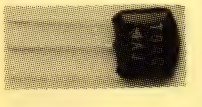

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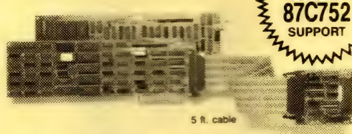

8051

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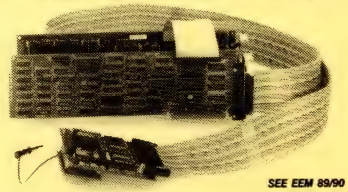

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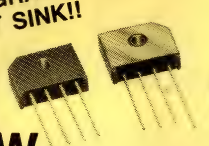

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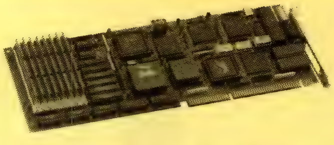

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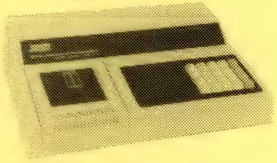

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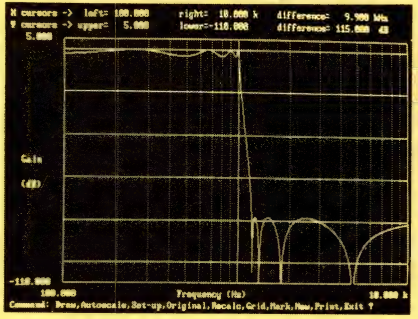

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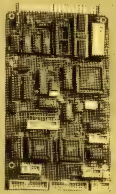

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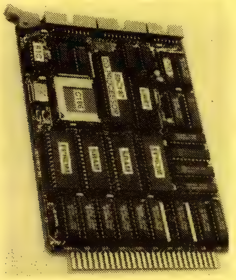

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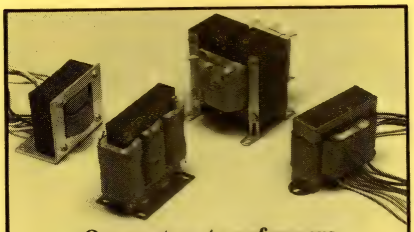

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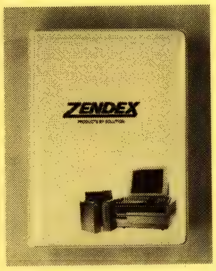

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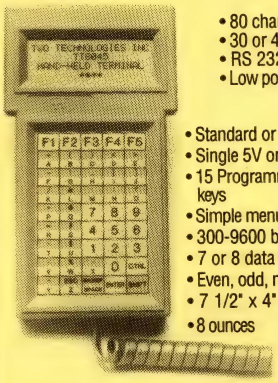

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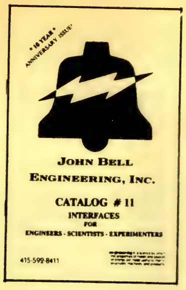
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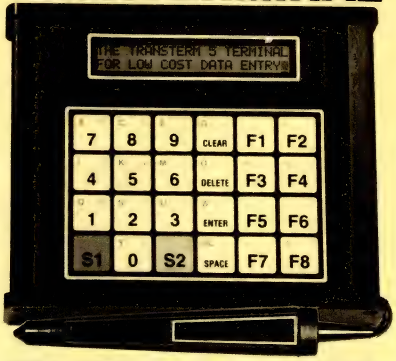

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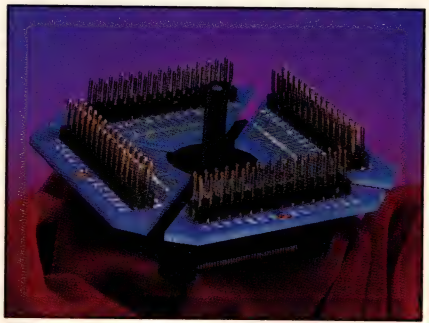

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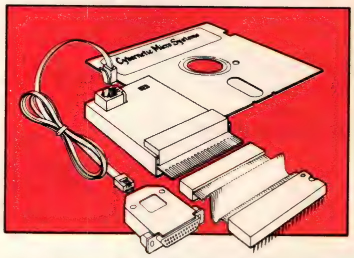

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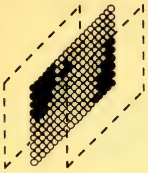

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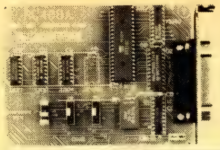

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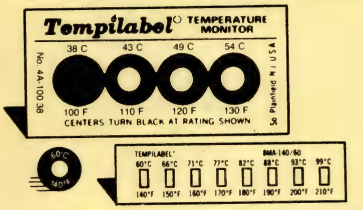
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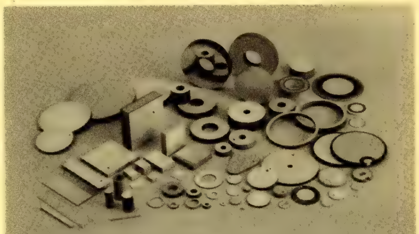

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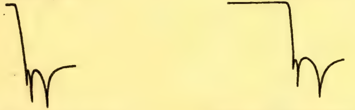

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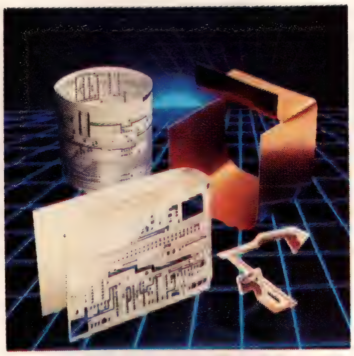

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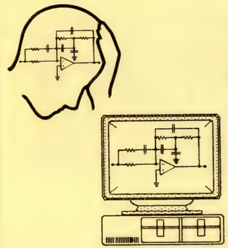

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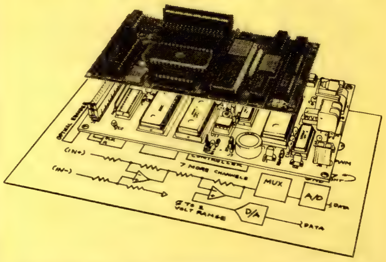

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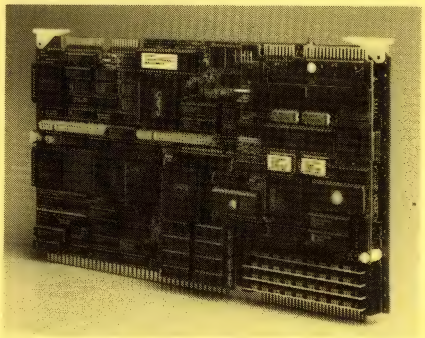

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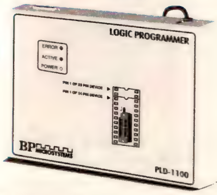

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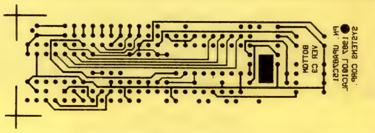

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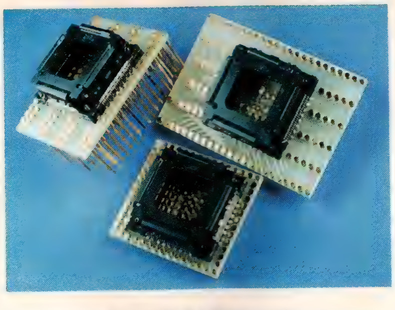

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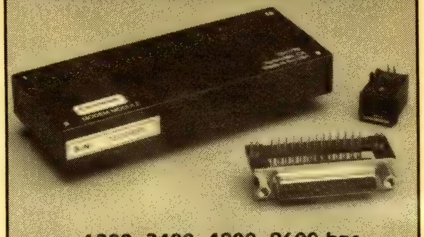

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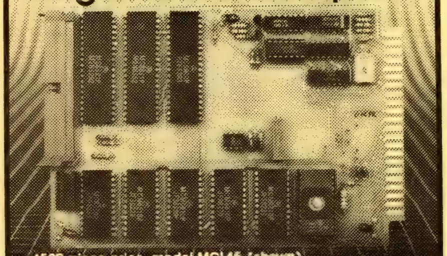

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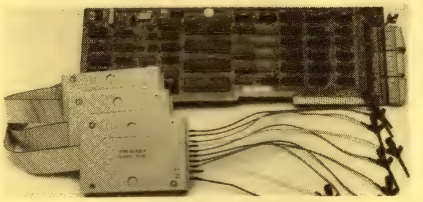

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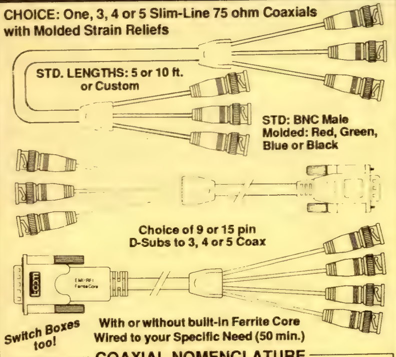
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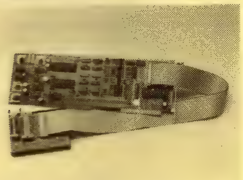

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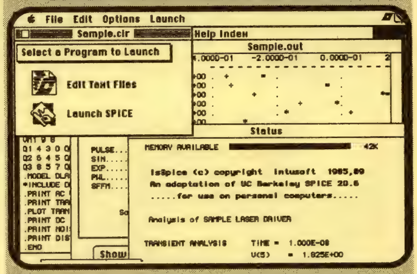

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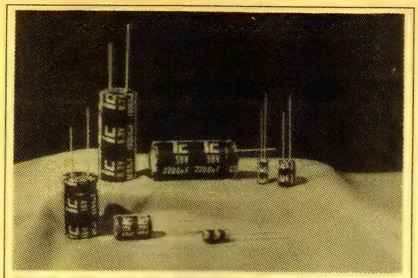

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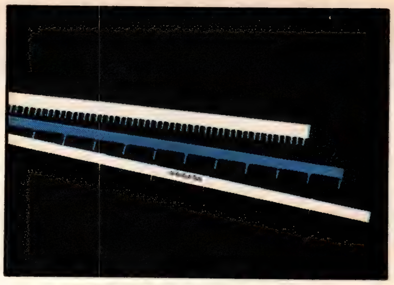

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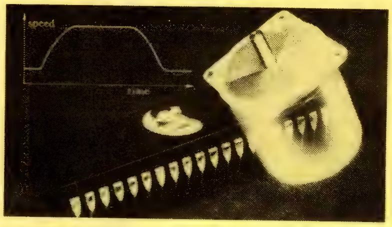

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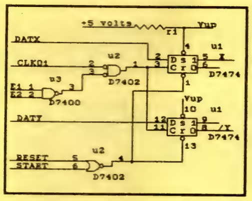

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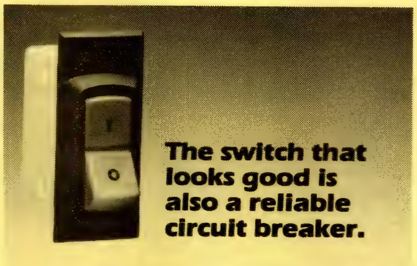
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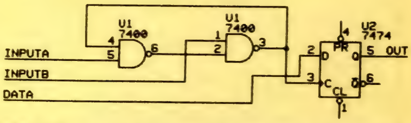

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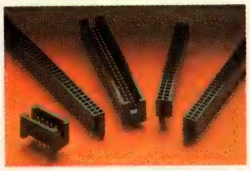

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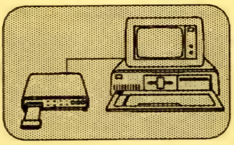

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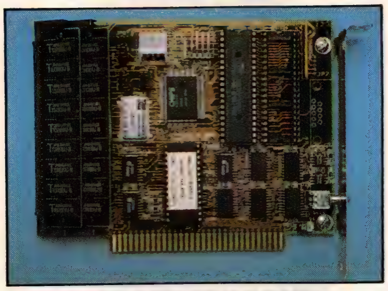

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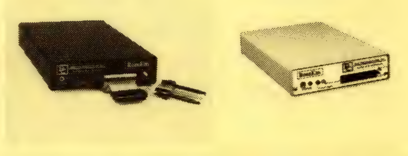

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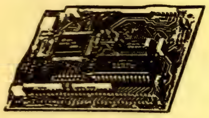

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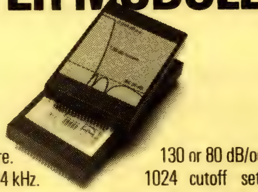

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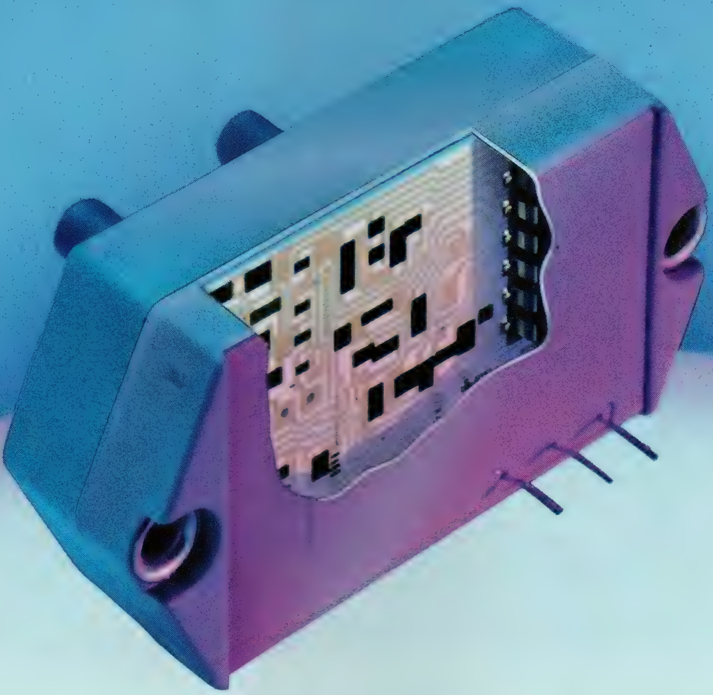

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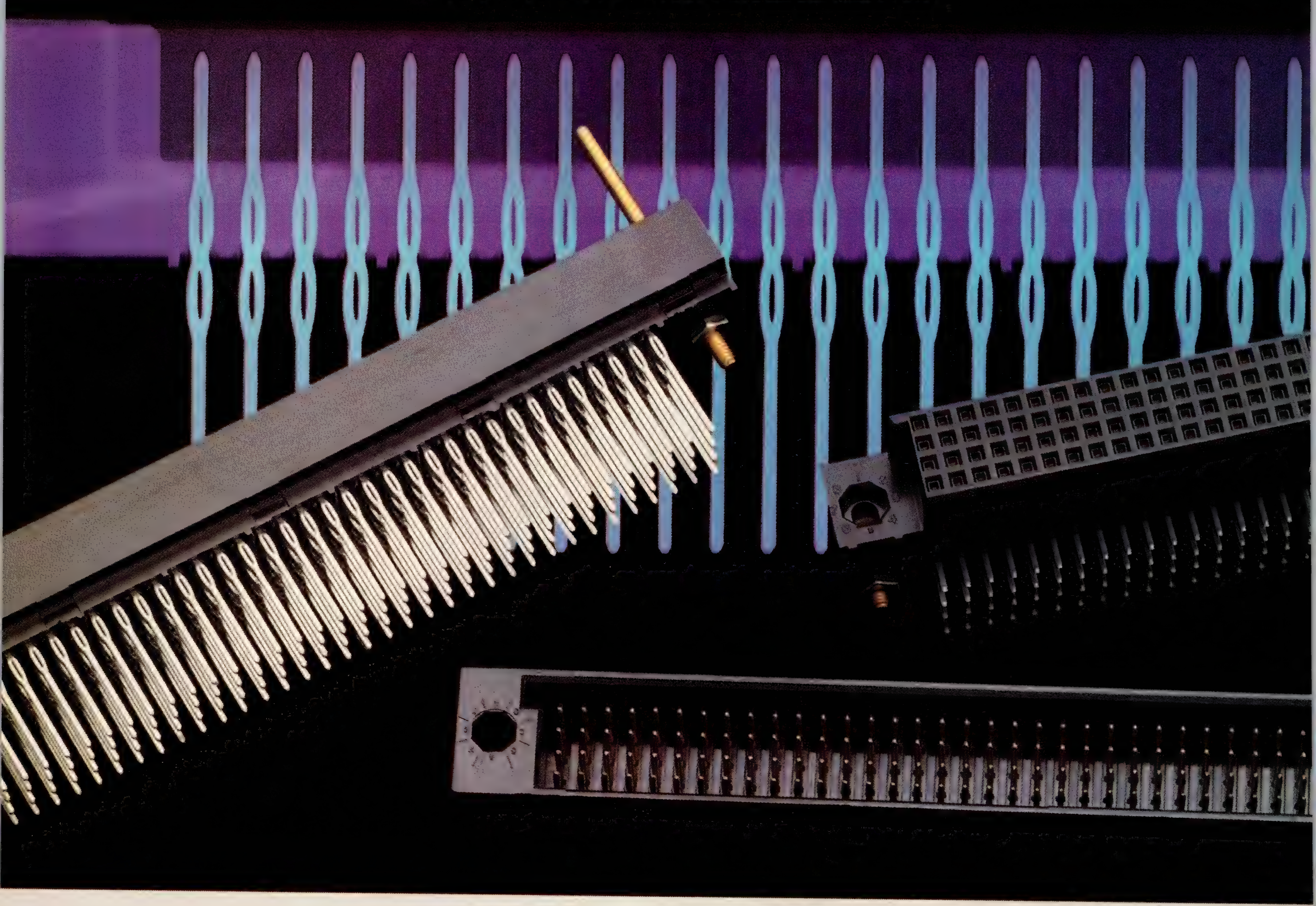

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Bush's budget closes some doors, opens others

How new federal spending priorities may affect your job.

Jay Fraser, *Associate Editor*

Nineteen eighty-nine was an extraordinary year. The repercussions from momentous events such as the signing of the US-Soviet Strategic Arms Limitation Treaty and the crumbling of communism in Eastern Europe will be felt around the world for years to come.

In America, one effect of the lessening of tensions with the Eastern Bloc will be a decrease in the level of defense spending. Approximately one-third of all engineers in the US work on projects related to national defense, and any significant drop in military spending is bound to result in cutbacks and layoffs.

The federal budget for 1991 that George Bush proposed in January included a 1.9% increase in defense expenditures. However, adjusted for inflation, that amounts to a 2% decrease in actual spending. Secretary of Defense Richard Cheney has projected the same 2% decrease in military spending for each of the next five years.

Bush's budget doesn't call for across-the-board reductions. Some programs will be canceled completely. Some will be cut back. Some will be left untouched. And some will actually receive increased funding.

"Our prediction at this point is that they're going to try to protect RDT and E (research, development, test, and evaluation) as much as possible. The emphasis will be on cutting production and procurement," says Sal Monaco, Director of Defense and Aerospace Practice at DRI/McGraw-Hill in Washington, DC.

"Engineers who are working in the basic research areas, people with advanced degrees, and people who are leading-edge engineers and physicists in the R and D professions are probably not going to feel much of a pinch. We estimate about a 1% per year decline there," he adds.

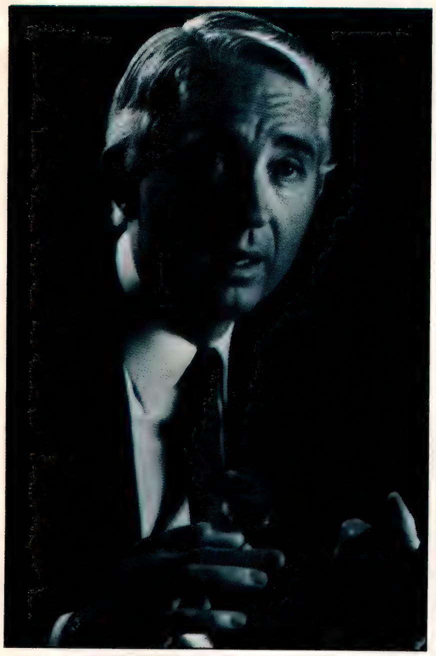
"On the other hand, those who are involved in the production of weapons systems, missiles, aircraft, and so on will feel more of an impact, on the order of a 4 or 5% decline."

Large cuts in military spending could have serious consequences for some companies doing defense work, especially those that are not diversified into other fields. During the Reagan era defense spending grew at a compounded annual rate of about 10%. Defense contractors were able to enjoy substantial growth simply by maintaining—not increasing—their share of the market. With the coming drop in military spending, some of these firms

Howard Sachs

"A lot of the big companies are going to start invading territory they've usually left to smaller companies."

SAL MONACO



“The defense electrical engineer has to develop a different skill set and design more for cost and manufacturability.”

WILLIAM SOMMERS

are facing zero growth or even serious losses. Defense contractors can counteract this trend in two ways: increase their market share or find new markets.

“This probably means that a lot of the big companies are going to start invading territory that they have usually left to smaller companies,” says Monaco. “Systems integration is one example. A lot of the major suppliers have kept away from that. In the last few years it’s become a very lucrative area. Big companies are now turning their attention to $10 to $20 million jobs that they used to consider not worth their time.

“Another reason I think smaller suppliers are going to have a problem is that the big companies are going to turn to themselves first, before they turn to subcontractors. They’re going to start to do some subassembly work and some component work that they’ve ignored in the past.”

Cuts will kill major programs

Bush has proposed terminating 15 major weapons programs. The following is a list of the most expensive ones and the money that would be saved by their cancellation:

- The V-22 Osprey tilt-rotor aircraft, $1.4 billion
- The M-1 tank, $1.1 billion
- The Apache helicopter, $682 million
- The F-14D jet fighter, $469 million
- The Maverick air-to-surface missile, $367 million
- The Phoenix missile, $333 million.

In addition, Bush has called for the closing of 35 military bases and the reduction of forces at 20 others in the US and the closing of 12 bases and the reduction of forces at two others overseas. He has also proposed the deactivation of two entire army divisions.

Despite these major cutbacks, some defense analysts are predicting growth in some areas of military spending and new opportunities for electronics engineers. William Sommers, Senior Vice President at Booz, Allen, and Hamilton in San Francisco, says, “There’ll be troop withdrawals from Europe. There’ll be base closings. There’ll be some programs canceled. But at the same time there’s going to be a lot of pressure to continue surveillance, to keep the modernization of the airlift capability going, and to have all sorts of verification technologies in place. That’s all heavily in the electronics area.

“There’s some pretty high growth still forecast in tactical missiles, in various forms of sensors, in C^3I (command, control, communications, and intelligence gathering), and in smart munitions—the marriage of sensors and munitions technology. It’s a small business, but growing very rapidly,” Sommers adds. “There’ll also be growth in avionics in general because airframes are so expensive that they’ll continue to upgrade the performance of existing aircraft by putting in new electronics, as is being done on the P-3, the antisubmarine warfare plane.”

Bush’s proposed budget contains a number of “big-ticket” items—the most expensive items—that would continue to be funded at the same level or would even receive increased funding. Among them are a Trident submarine, which would cost $1.45 billion; two smaller attack submarines with a combined price of $3.5 billion; 12 additional multiple-warhead MX missiles that would total $2.8 billion; and a prototype of the Midgetman missile that would cost $200 million to develop.

The value of some of these programs will be hotly debated. For example, many congressmen think the Midgetman missile is unnecessary and want to kill it. However, no programs are more controversial than the two most expensive ones in the budget—the B-2 Stealth bomber and the Strategic Defense Initiative (SDI).

Bush wants to spend $5.54 billion to procure five B-2s next year. Many people have questioned the bomber's mission, its ability to elude radar, and its price. The Air Force originally wanted to purchase 132 B-2s, but some lawmakers are talking about ending the program after only one-fourth of that number are built. Some are talking about canceling the program entirely.

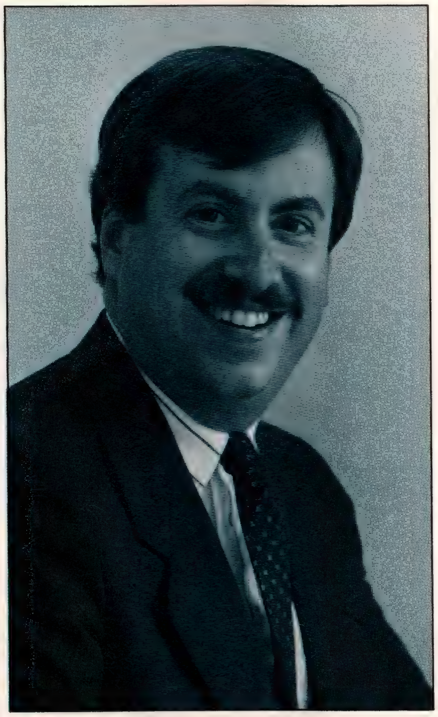
Bush also wants to increase funding for SDI by 22%, from $3.82 billion this year to $4.66 billion in fiscal 1991. This increase would make it the Pentagon's largest research project by far. However, there has always been strong opposition to SDI in Congress. Last year lawmakers actually made a small cut in its funding. Now, with the Soviet threat receding, many will not see the need for such a huge increase in SDI appropriations.

"Peace dividend" may disappear

Although they differ on which programs should be cut and by how much, both the administration and Congress want to reduce defense spending. Some people have claimed that this will result in a "peace dividend," and they want the money diverted from the military to be applied to social programs. But some industry observers believe that talk of a peace dividend is overly optimistic.

"I don't know that it's going to be as much of a windfall as some people seem to think," says John Mancini, Vice President of Domestic Public Affairs for the American Electronics Association in Washington, DC. "When people talk about the huge increase in growth that's going to come about as a result of the decline in the defense budget, there's one common element in all their predictions, and that's that the bulk of any peace dividend that occurs is used to attack the budget deficit. That brings down interest rates, which in turn increases investment.

"All of the long-range forecasts that I've seen premise some short-term difficulties. And that is going to be a real challenge for Congress. It's great to say there are going to be huge defense cuts, but in the short term that's going to have a real impact on a lot of communities."



"All of the long-range forecasts that I've seen premise some short-term difficulties."

JOHN MANCINI

To maintain their sales during the rough times ahead, defense contractors can do work for other departments of the federal government. NASA is the agency most likely to be expanding in the future. It's heavily involved in high-tech R and D. It has begun a number of long-term projects. And the Bush administration is committed to increasing its funding. If Bush's budget is passed, NASA will receive $15.2 billion in 1991. This figure is an increase of $2.9 billion or 23% over 1990—the largest increase for any major federal agency.

NASA has already embarked on three ambitious projects:

- The construction of the manned space station *Freedom*, which will receive $2.4 billion in 1991. The program will eventually cost $30 billion before the station goes into orbit in 1995.
- The Earth Observing System, a network of satellites to monitor the earth's ecology, which will receive $235 million next year. This is part of the 25-year-long "Mission to Planet Earth," which will cost a total of $17 billion.
- The development of the technology to send American astronauts back to the moon by 2010 and then to Mars by the middle of the 21st century. The down payment in 1991 will be $225 million.

However, high-tech firms can't depend on increases in the NASA budget to take up the slack as defense spending declines.

"Even if the NASA budget were increased by 10% each year, it still isn't going to make up for the drop in the defense budget," says Monaco. "What I think the NASA budget will do, though, is keep the research-and-development base we have alive."

Another area defense contractors could move into to offset diminished military spending is commercial markets. But defense contractors have a poor track record when it comes to selling to the general public.

"The big guys have been burned before by trying to get into commercial markets," says Monaco. "What they'll do is turn their attention to commercial markets that are as much like the Department of Defense as possible. Environmental cleanup would be one area, for instance. Telecommunications would be another."

"Military electronics firms have difficulty becoming commercial electronics firms because the business models are so different," says Sommers. "The defense electrical engineer has to develop a different skill set and design more for cost and manufacturability. There's a big difference between building a one-of-a-kind, advanced, state-of-the-art device versus doing the engineering for something that's going to be manufactured in the hundreds of thousands or millions of units."

The trends for at least the next five years are clear. Although the Bush administration and Congress differ on which military programs should be cut and by how much, defense spending is going to decrease significantly. At the same time, NASA's funding will increase, but that agency can't absorb all the engineers who will no longer be working on defense projects. This certainly isn't good news, but the future may not be as bleak as it appears.

"I think what's going to happen will depend on what the individual engineer does to retool his skill set and to be mobile within the job market," says Sommers. "I see telecommunications, software, consumer electronic systems, networks, and systems integration all as high growth. The marriage of optical and electrical systems, whether in computers or in telecommunications—high growth. Continued improvement in various kinds of electronic instruments—high growth. Process control, control of industrial processes of all kinds—high growth. There are lots of opportunities."

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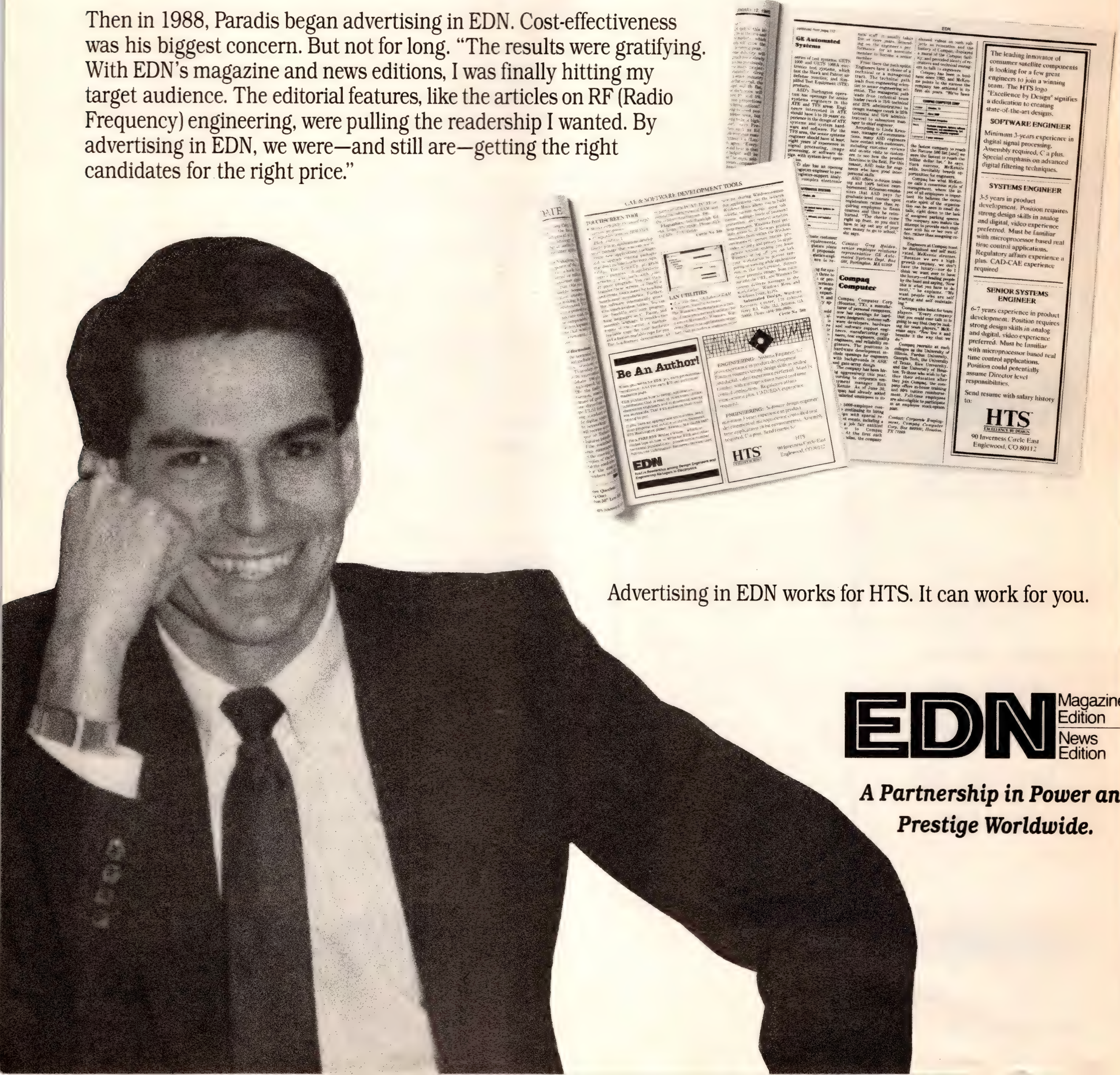
Then in 1988, Paradis began advertising in EDN. Cost-effectiveness was his biggest concern. But not for long. "The results were gratifying. With EDN's magazine and news editions, I was finally hitting my target audience. The editorial features, like the articles on RF (Radio Frequency) engineering, were pulling the readership I wanted. By advertising in EDN, we were—and still are—getting the right candidates for the right price."



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POSITION DESIRED

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Duties and Accomplishments: Industry of Current Employer: ________________

Reason for Change: ________________

PREVIOUS POSITION:

Job Title: ________________

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Division: ________ Type of Industry: ________ Salary: ________

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Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation

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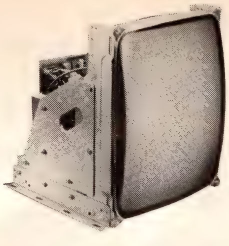
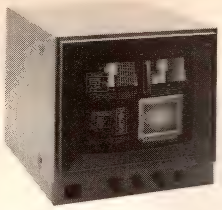


HI RES Monochrome Monitors

MOD 100™ Series monitors are designed for desktop publishing systems and any application that requires high resolution graphics. The Series features up to 100 kHz scanning frequencies and 120 dots/inch resolution. CRT sizes are 15, 17 and 19″ (110 or 114°). Two-axis dynamic focus is offered for optimum character sharpness. Video bandwidth is 160 MHz. Switching video is standard; analog or 4 level video are offered as options. Power requirements are 24V at 2.2 amps. Switching power supply is optional (110/220 selectable).

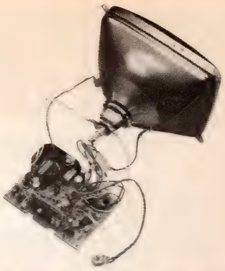
CIRCLE NO. 99



Compact Multi-Scan Color Monitor

UL/CSA listed 9″ Multi-Scan monitor with an active view area of approximately 160 x 115 mm is designed for financial, instrumentation and medical electronics applications. This Series automatically adjusts scan rate. Horizontal frequency ranges from 15 to 35 kHz and vertical from 50 to 110 Hz with automatic size control for both axis. Trio spacing is 0.26 mm; misconvergence is less than 0.8 mm. Video bandwidth is approximately 30 MHz. Video input is TTL level and it can be set to automatically switch to analog. Sync is TTL level with auto polarity.

CIRCLE NO. 100



Monochrome VGA Series Monitors

Customizer™ VGA Series B/W monitors are available with a variety of faceplate treatments and are designed for computer, test equipment, instrument and medical electronics applications. P4 phosphor CRTs of 12 or 14″ provide a resolution of 900 lines (center), 750 lines (corners). Other phosphor types are optional. Horizontal frequency is 31.5 kHz (standard); vertical frequency is 60 to 70 Hz. Linearity is better than 10%. Operating temperature range is 5 to 55°C. Power requirements are +12V input at 2.2 amps typical.

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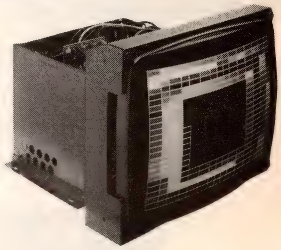
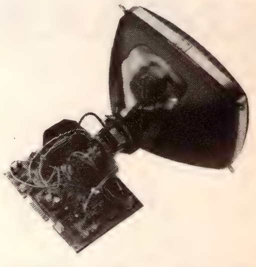


VGA Series Color Monitors

UL/CSA listed Prismatic™ VGA Series color monitors are designed for medical electronics and instrumentation applications. Resolutions can be set for VGA modes 1, 2 and 3. CRT sizes range from 9 to 19″ (diagonal measure) with a standard trio spacing (19″ display) of 0.31mm. Video input is RGB analog; Sync input is positive or negative TTL. Vertical scan frequency is 60 to 70 Hz; bandwidth is 25 MHz typical and the unit's rise time is less than 15 nsec. Operating temperature range is 0 to 55°C.

CIRCLE NO. 102



Compact Monochrome Monitors

UL/CSA/VDE listed Customizer II™ monochrome monitors with P4 phosphors provide a resolution of 900 lines (center), 750 lines (corners). Other phosphors are available as an option. CRT sizes are 5, 7, 9, 12 or 14″ (diagonal measure). Horizontal frequencies of 15.7, 18.6, 20.7 or 22.6 kHz (± 500 Hz) are standard; other frequencies optional. Linearity is better than 10%. Operating temperature range is 5 to 55°C. 10-pin edge connector is standard; others are optional. Various faceplate finishings are available. This Series is ideal for applications requiring compact design and low power consumption.

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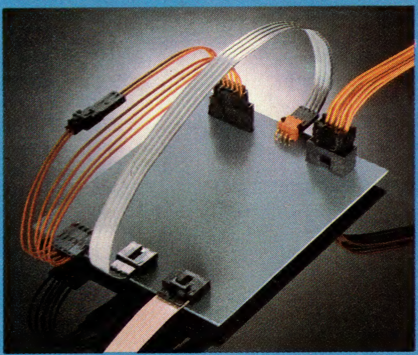

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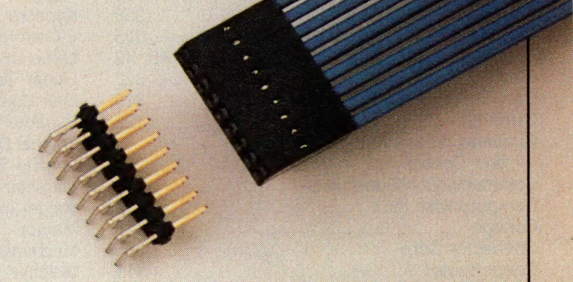

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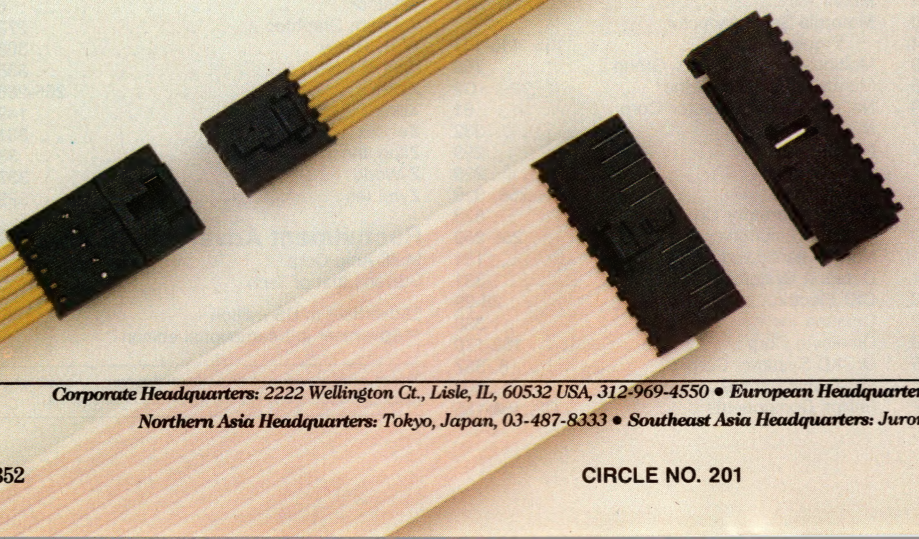

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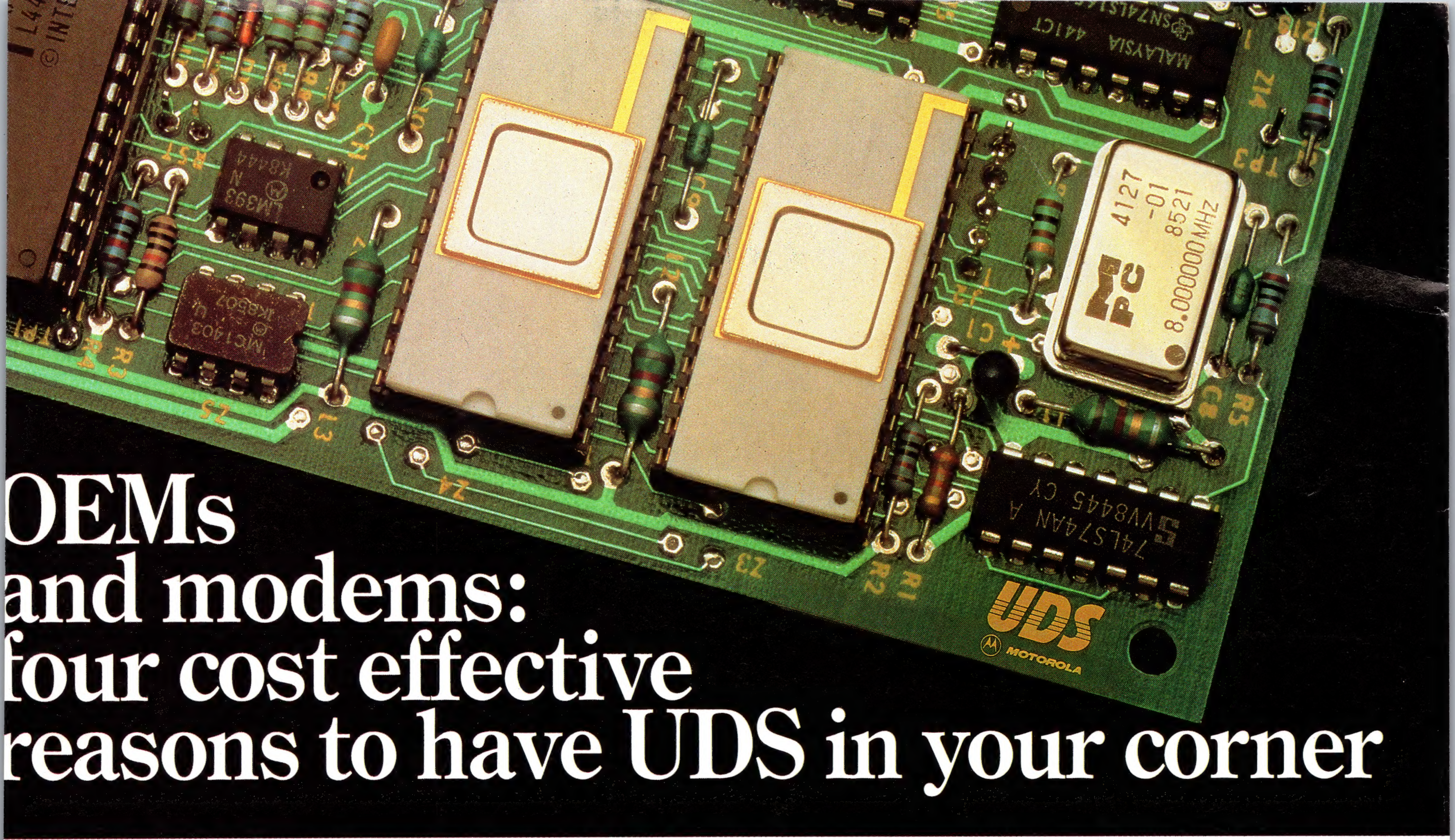
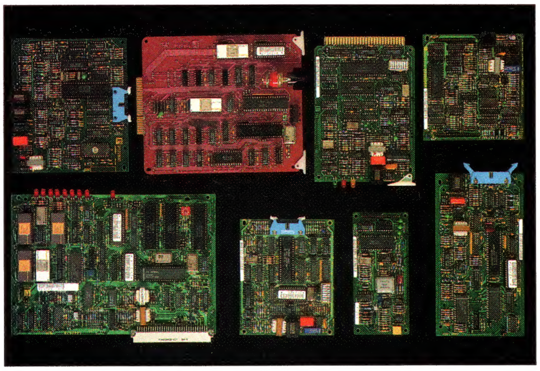


OEMs and modems: four cost effective reasons to have UDS in your corner



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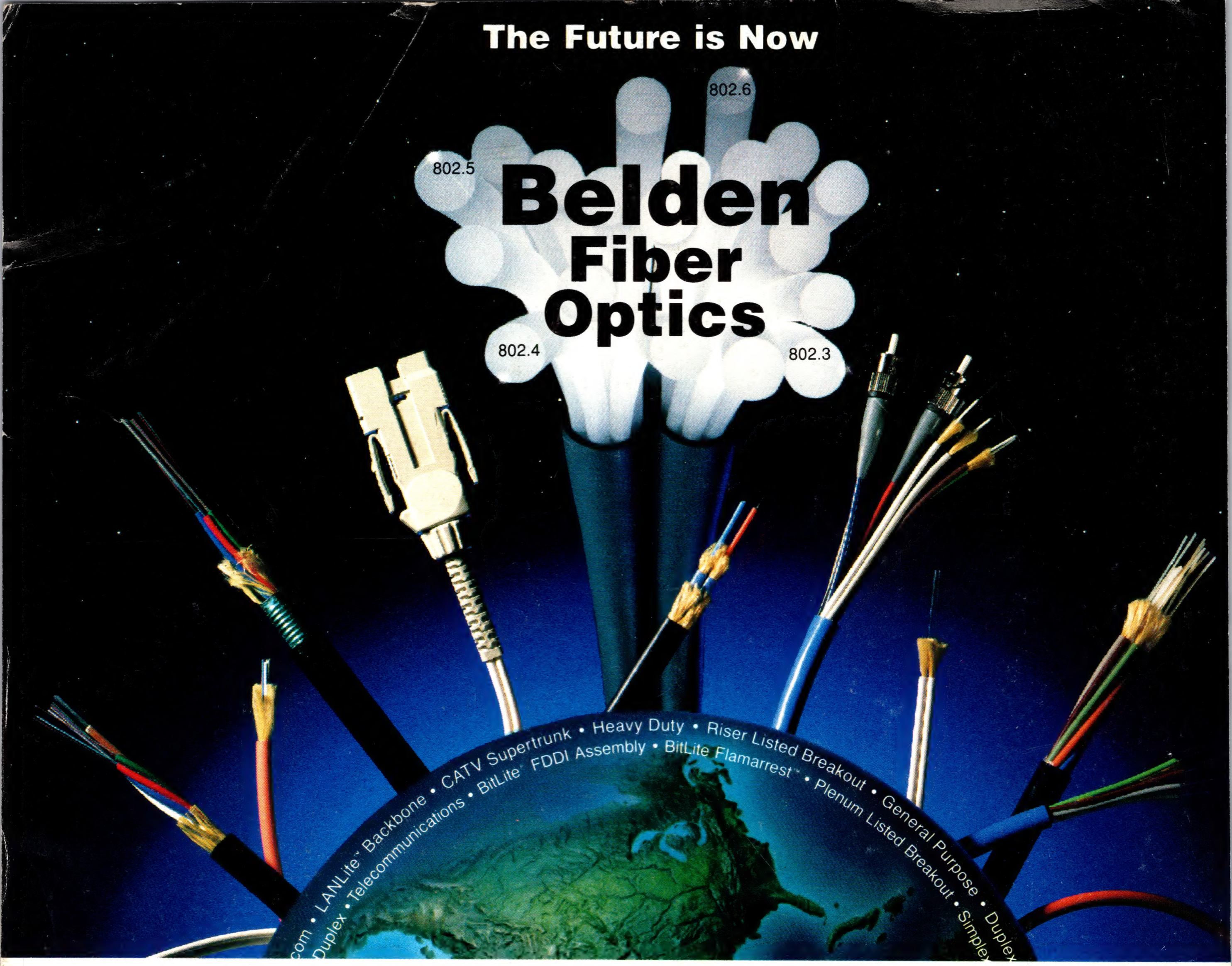
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